



Improved Performance Research Integration Tool (IMPRINT)

User's Guide

Version 5.0

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DRAFT

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Improved Performance Research Integration Tool (IMPRINT) User's Guide

Chapter 1 - Getting Started in IMPRINT

The Improved Performance Research Integration Tool (IMPRINT) was developed for the Army Research Laboratory (ARL) Human Research and Engineering Directorate (HRED). IMPRINT is Government-owned and consists of a set of automated aids to assist analysts in conducting human performance analyses. IMPRINT provides the means for estimating manpower, personnel, and training (MPT) requirements and constraints for new weapon systems very early in the acquisition process.

Some of the key features of IMPRINT are:

- Includes extensive MPT data libraries on existing weapon systems
- Estimates operator and maintainer manpower requirements at the system, unit and force levels
- Projects future manpower levels and personnel characteristics
- Provides task-based analyses that predict changes in performance as a function of changes in personnel characteristics
- Predicts performance effects of environmental stressors and sustainment training frequency
- Estimates crew workload
- Contains mission simulation models that aggregate task performance

IMPRINT is distributed by ARL HRED. The technical point of contact is Dr. Laurel Allender (410) 278-6233 (lallende@arl.mil).

Organization of this Document

This User's Guide is organized into seven chapters. In the first chapter, we describe some basic concepts related to IMPRINT. It describes the requirements of the computer system that you need, and also describes some basic techniques that apply to the IMPRINT product. In the second chapter, we describe how to install IMPRINT. IMPRINT is available on CD or diskette. In the third chapter, we describe the capabilities of IMPRINT. This chapter is organized hierarchically, in the order of the menu items of IMPRINT. Chapter 4 includes a technical description of how the Operations models execute in IMPRINT. The fifth chapter includes a technical description of the maintenance manpower model that is embedded in the IMPRINT tool. The sixth chapter describes IMPRINT errors that you might see and how you can respond. Finally, the seventh chapter provides a glossary of terms. At the end of this document, we have provided a section for references as well as an index. Finally, we have included an appendix that includes a technical paper that discusses the implementation of stressor data in the human performance modeling capabilities of IMPRINT.

An IMPRINT Analysis Guide is available that discusses in detail the types of analyses that you can perform with IMPRINT, and the steps you go through to accomplish each type of analysis. If you are new to the IMPRINT product, we recommend that you review that document. Additionally, an IMPRINT Quick Start Guide is available. It provides a very brief description of some of the key capabilities of IMPRINT. Both of these documents, along with other reference materials are available through Dr. Allender at ARL HRED (410) 278-6233.

A significant portion of the functionality available in IMPRINT was provided in a DOS-based tool set called Hardware vs. Manpower (HARDMAN) III. HARDMAN III was a major development effort of the Army Research Institute's (ARI) System Research Laboratory (which has now become part of the Human Research and Engineering Directorate of the Army Research Laboratory). HARDMAN III is Government-owned software and provided the means for estimating manpower, personnel and training (MPT) constraints and requirements for new weapon systems. More information on the capabilities of the original HARDMAN III tools can be found in the HARDMAN III Final Report (Adkins and Dahl, 1993).

Basic IMPRINT Information

There are several things about IMPRINT that it is useful for you to know before you begin using the application.

The minimum amount of RAM needed to run IMPRINT is 32MB.

IMPRINT uses a database manager called WATCOM. When WATCOM opens a database (such as the IMPRINT library) it creates and displays an icon for that database.



Watcom icon

If you are not running IMPRINT in a maximized full screen mode or are using a taskbar, you will see these icons. You should ignore the icons. They will go away when you exit IMPRINT.

Dialog boxes, similar to the one shown in Figure 1-1, are used throughout the application. Almost all the dialog boxes will have three common buttons.

The "OK" button, when clicked, accepts any input you entered within the dialog box and then closes it. **It is important to understand that the actions taken in the dialog box are put into temporary storage and not written to permanent storage on the hard disk.** In order to save the actions to permanent storage, you must use the main menu "File" - "Save" options (similar to saving a document in Word for Windows). **We recommend that you save your work frequently when conducting analyses with IMPRINT.**

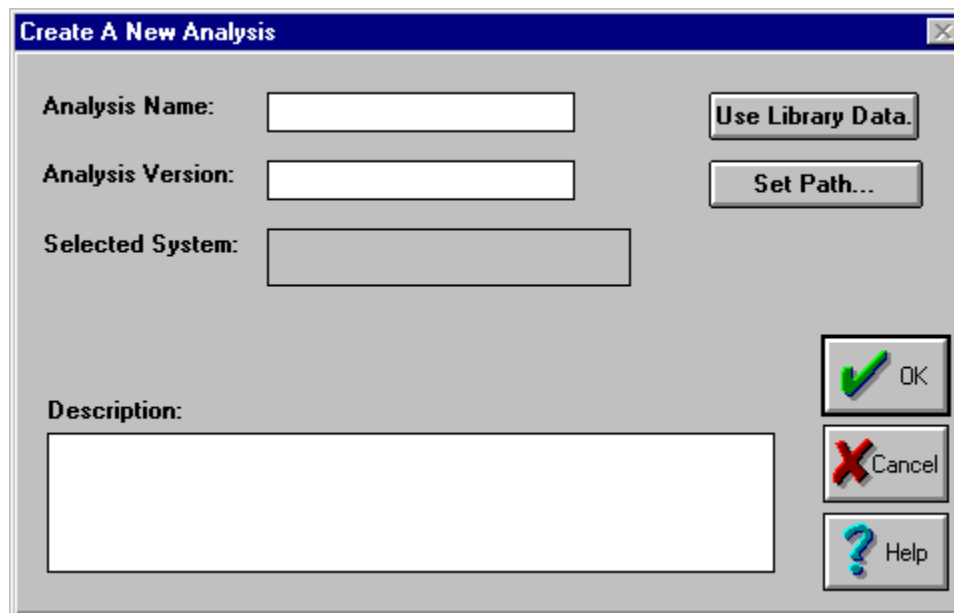


Figure 1-1. Example IMPRINT Dialog Window

The “Cancel” button, when clicked, discards any data you entered within the dialog box and then closes it.

The “Help” button, when clicked, provides context sensitive help for that particular dialog box.

To enter any time data, use the mouse to position the cursor in the time standard box. The format for all time values is hh:mm:ss.00. So to enter a time standard of 30 minutes, 15 seconds enter 00:30:15.00. Notice that you can enter hundredths of a second after the decimal point.

Basic Windows Information

As you work with IMPRINT, you will be accessing, entering, and manipulating information in the Microsoft Windows environment. IMPRINT is designed to be consistent with Windows user interface standards. If you are not familiar with other Windows applications, we have provided a brief description of the basic elements of IMPRINT windows.

Most of the windows in IMPRINT will have many elements in common. However, not every window has every element. For detailed information about all aspects of the Windows environment, refer to your Microsoft Windows User’s Guide.

The illustration below shows one IMPRINT window displayed on top of another. The notations point to common elements in both windows.

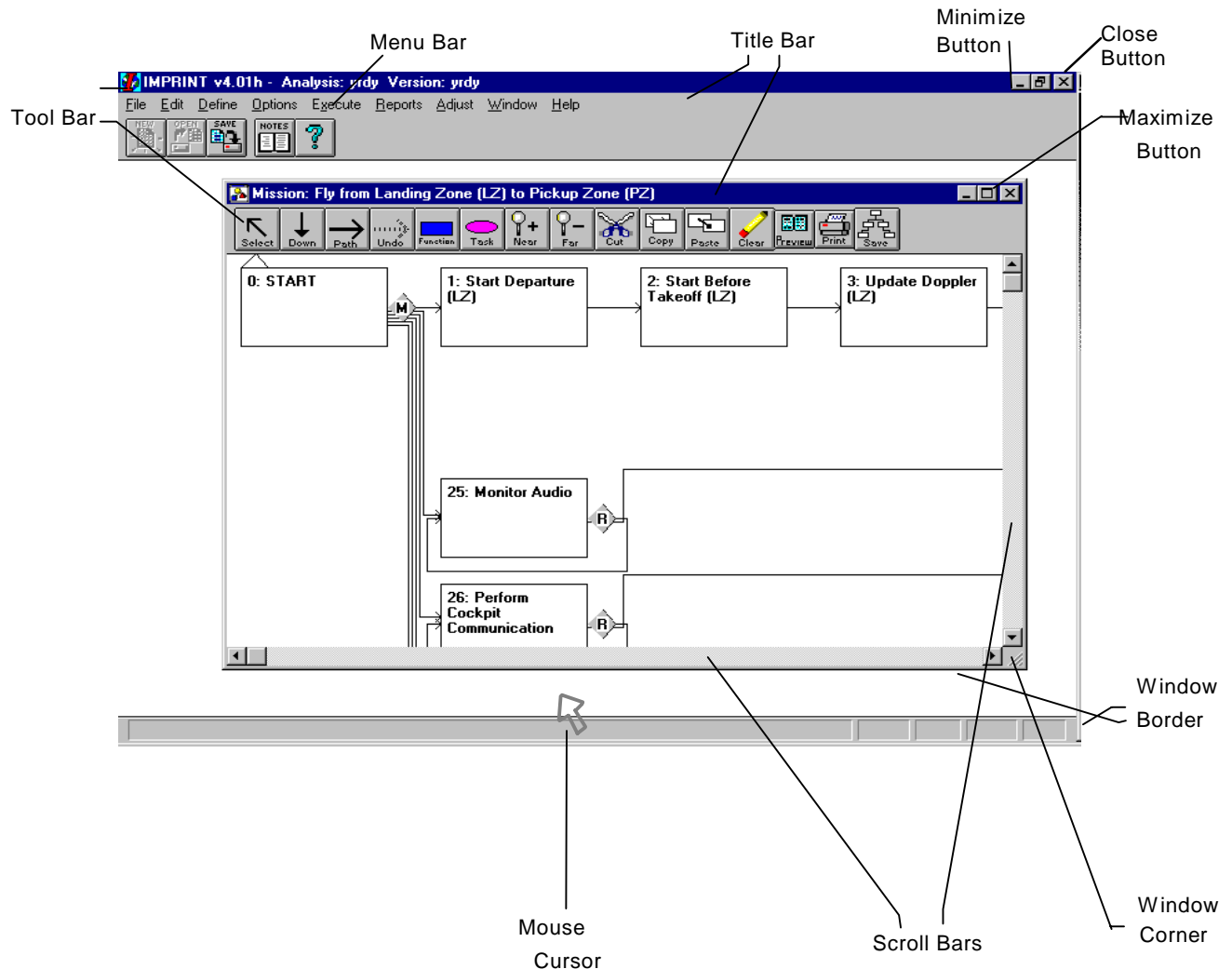


Figure 1-2. General Windows Layout (Windows 95)

Control Menu Box - The upper right corner of most windows contains the control menu box. When you click this box, the control menu displays. The control menu is most useful if you want to manipulate the window from the keyboard rather than with a mouse. By using the control menu, you can resize, move, maximize, minimize, and close the window. If you use a mouse, you can click and drag to perform these tasks.

Title Bar - Appearing at the top of the window, the title bar shows the name of the application, document, or window. If more than one window is open, as in the illustration above, the title bar for the *active* window (the one in which you are working) is a different color or intensity than other title bars. If you hold down on the mouse button while pointing to the title bar, you can drag the entire window to a different location on the screen.

Menu Bar - This bar shows the available menus. A menu contains a list of commands, actions, or options you can carry out in IMPRINT. The File menu, Edit menu, and Help

menu are common to many Windows applications. The Define, Options, Execute and Adjust menus are unique to IMPRINT.

Scroll Bars - The bars help you scroll either horizontally or vertically through the contents of a document to display information that will not fit in the window. You can use scroll bars to view unseen portions of lists and other information that cannot fit in the allotted space of the window.

Maximize Button - When you click this button, you will enlarge the active window so that it fills the entire desktop workspace.

Minimize Button - Lets you reduce the window size to an icon.

Restore Button - After you enlarge a window to its maximum size, the Maximize button is replaced by the Restore button which contains both an up and a down arrow. You can click the Restore button to return the window to its previous size. From the keyboard, you can select the Restore option on the Control menu to perform the identical function.

Command Buttons - You choose a command button to initiate an immediate action, such as carrying out or canceling a command. The OK and Cancel buttons are common command buttons. They are often located along the lower right side of a dialog box window.

Window Border - This is the outside edge of the window. You can lengthen or shorten the border on each side of the window by pointing to it with the mouse cursor and holding the mouse button down while you drag the mouse in the desired direction.

Window Corner - Use this to lengthen or shorten the two adjoining sides of a window border at the same time.

Mouse Cursor - Appears if you have the mouse installed. When you move the mouse, the position of the pointer changes on the screen. The shape of the cursor itself depends on the location of the cursor on the window. For example, when the cursor is on the menu bar, it looks like an arrow. When the cursor is in a typing field, it looks like an upper case "I" to represent the insertion point.

Chapter 2 - Installing IMPRINT

You will receive IMPRINT on either a CD or as a set of several 3 ½ inch diskettes. The instructions in this chapter apply to either media.

You can install IMPRINT onto any drive of your PC. This does include LAN drives. If your PC already has a version of IMPRINT installed, and you want to continue to have access to the analyses you have developed with that previous version, we recommend that you export each analysis you want to keep and store them for safe-keeping prior to installing IMPRINT Version 4. Then, install Version 4 into the same directory as your old IMPRINT. IMPRINT will not erase your previous analyses, and when you open them, IMPRINT will automatically convert them to the Version 4 format.

If you want to have access to two different versions of IMPRINT at the same time, please contact technical support for guidance. It can be done but is not recommended because if IMPRINT Version 4 is installed into a different directory than the existing IMPRINT, then the previous version of IMPRINT will no longer be attached to the correct database. This is because IMPRINT uses directory identification information that is stored in the IMPRINT.INI and ODBC.INI files that are stored in your Windows or WinNT directory.

Follow these steps to install IMPRINT Version 4.0:

1. Place the CD or the first diskette in the appropriate drive of your PC.
2. From the Start Menu in Windows 95 or Windows NT, select the “Run...” command
3. At the prompt on the “Run” menu, enter the drive letter where you have put the IMPRINT disk, and type “Setup.” As an example, if you have put an IMPRINT CD in the D drive of your machine, you would type D:\Setup.
4. The installation program will display the IMPRINT logo and will take a few seconds to initiate. Then, you will see a dialog that reminds you that you should not install IMPRINT Version 5 unless you are finished using the previous version. Click on the “OK” button if you want to continue installing IMPRINT. Click on the “Cancel” button to halt installation.
5. Next, you will see an introductory screen that identifies IMPRINT and notes that it was developed by the Army Research Laboratory, Human Research and Engineering Directorate. Click on the “Next” button to continue installing IMPRINT.
6. On the next screen, IMPRINT will ask you to identify the directory into which you want to install the software. You can use the “Browse” button on this screen to search through your directory structure and find the directory you want. You can also type in a directory name that does not exist. IMPRINT will create that directory for you. Then, click on the “Next” button to continue installing IMPRINT.
7. IMPRINT contains several modules that are necessary to support the variety of operating systems under which you can run the product. On this next screen, you will notice a list of modules. Two of these modules are operating system-specific.

These are Windows NT and Windows 95. You can click on these modules to deselect them. IT IS VERY IMPORTANT that you deselect one of these modules. MAKE SURE that you only have selected the one module that is appropriate for your operating system. These modules contain Dynamic Linked Library (DLL) files that are operating system-specific. If you do not select the correct ones, IMPRINT and other applications may not run correctly. If you make an error on this screen, please contact technical support and we will assist you in correcting the error. When you have deselected the inappropriate module, click on the “Next” button to continue installing IMPRINT.

8. The next step lets you identify a program group for the IMPRINT application. This will become the label under which you find IMPRINT when you access your Programs in Windows. You can either select an existing group, or you can enter a new name. Click on the “Next” button to begin installation.
9. After the installation is complete, you should reboot your computer before attempting to use IMPRINT.

Chapter 3 - Using IMPRINT

Introduction

This chapter provides a detailed description of the menu items available in IMPRINT. It is organized in the same order as the IMPRINT menu items themselves, proceeding from left to right, top to bottom, beginning with the items on the “File” menu, and concluding with the items on the “Adjust” menu.

If you have questions regarding the capabilities of IMPRINT and how you would use it to answer your specific questions about your system, we recommend that you refer to the IMPRINT Analysis Guide. This document is available from ARL HRED.

File Menu

New

You use this menu option to begin working on a new analysis.

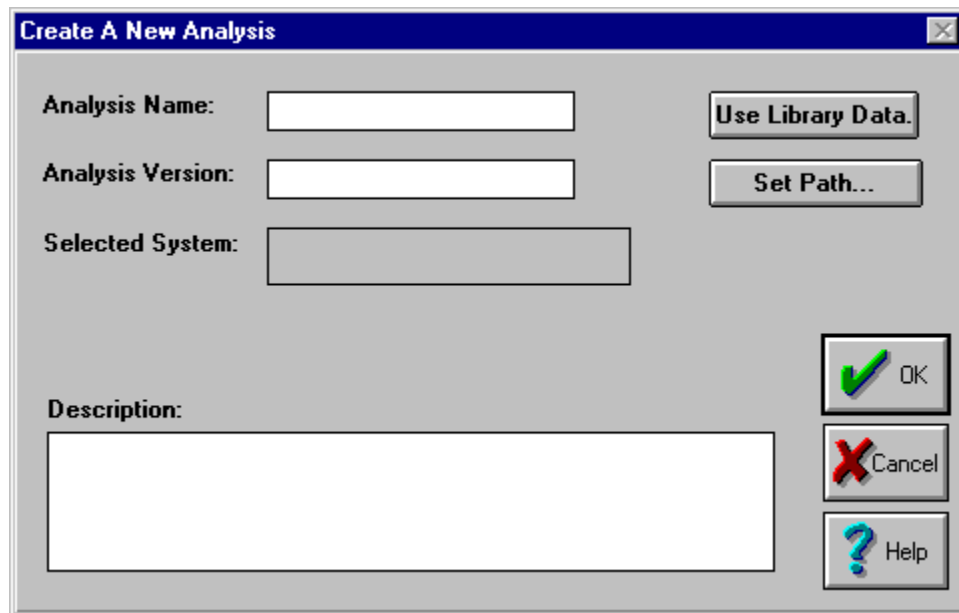


Figure 3-1. Create A New Analysis

From the main menu option “File” choose “New” or click on the “New” icon on the tool bar. This will display a dialog box which is used to name your new analysis. You must enter both an “Analysis Name” and an “Analysis Version.” Those two names uniquely identify your analysis. Optionally, you can also enter a textual description of your analysis so that you will have a reminder of what the analysis is about when you recall it at a later date.

Use Library Data Button

IMPRINT contains libraries of data on numerous currently fielded Army systems. The purpose of these data is to provide you with a starting point for conducting your analyses. For example, if you want to conduct an analysis in support of a new tank, you could load the mission models for the M1 tank for reference, and then modify these existing missions to reflect the missions of your new tank.

To use the library data, click on the "Use Library Data" button that is on the "Create New Analysis" dialog. When this button is pressed, a list of all the weapon systems for which IMPRINT contains data will be displayed. You can select the system that is closest to your new system and then press the "OK" button. This will cause the library data for the selected system to be copied into your analysis database. The mission, soldier and equipment data associated with that library system will be available for you in subsequent dialogs.

The library systems available in IMPRINT include:

System Name	System Type
M977 HEMTT	Heavy Truck
M998 HMMWV	Light Truck
OH 58D	Scout Helicopter
UH-60A	Utility Helicopter
CH 47D	Cargo Helicopter
AH-64A	Attack Helicopter
M2 Bradley	Infantry Fighting Vehicle
M901 ITV	Anti-Tank Vehicle
Dragon	Man-portable Anti-Tank Weapon
M203	Grenade Launcher
M16A1	Rifle
M249 SAW	Automatic Weapon
M1 Abrams	Tank
Lance	Medium Range Missile Artillery
M109A2	Self-propelled Howitzer
M252 81MM	Man-portable Indirect Fire Weapon
M3 Bradley	Cavalry Fighting Vehicle
M102	Towed Howitzer
MLRS	Rocket Field Artillery System
Stinger	Man-portable Air Defense System
Patriot	HIMAD
M163 Vulcan	Air Defense Mobile Gun

Set Path Button

Click on this button to set the path for saving your analysis to a drive or directory other than the current one (e.g., c:\imprint).

Open

You should use the “Open” menu item to open an existing analysis.

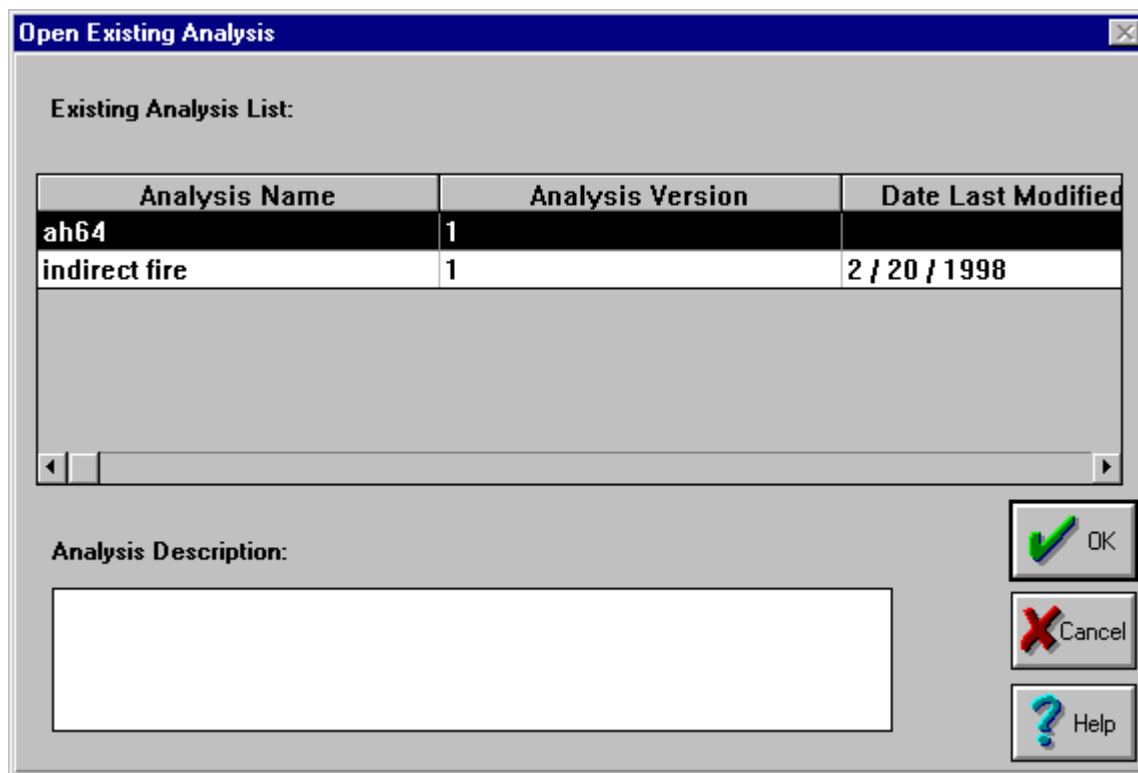


Figure 3-2. Open Existing Analysis

From the main menu “File” option choose “Open” or click on the “Open” icon on the tool bar. This will give you a list of all the Analysis Names and Versions that are stored in your working files and are available for you to resume work on. In addition, it provides the date you last worked on that system and version. When you select a system and version to resume work on, be aware that any changes made will be permanent and old data will be lost. To preserve all your previous work and, at the same time, be able to make changes to that work, you should copy the analysis using the “Save As” option on the main menu item “File” and make the changes on the copy (which will now be saved under a different system or version name).

To select a system and version from the list, highlight it and click the “OK” button. You will see two dialog boxes with progress bars appear. Your analysis will be open after they have completed. The analysis name is then listed in the title bar of the IMPRINT window. Then, IMPRINT is ready for you to select other options.

Close

Use this command to close your analysis. You must close an analysis before you can open a new one. This command does not close IMPRINT. If you have not saved all the changes you have made to your analysis when you try to close it, IMPRINT will prompt

you so that you can specify whether you want to save or delete the changes you have made.

Save

Use this command to save all the changes you have made to your analysis. We recommend that you save your analysis often! IMPRINT does have an automatic save option. Every 10 minutes, IMPRINT automatically saves your database to a file named autosave.db. If you do experience a catastrophic failure in IMPRINT and fear that you have lost data, you can recover it through this file. To recover data, you must first determine the file name for the database you were working on when the failure occurred. To do this, look at the dates and times at the files in your IMPRINT directory that are named imp*.db. When you identify the one that you were working on most recently, you should save that file to another name (just to be cautious) and then rename autosave.db to that same file name (impXX.db). Then, you should be able to open IMPRINT again, and proceed normally.

Save As

Use this command to save your analysis under a new name. When you select this command, you will be prompted to enter a new Analysis Name and Analysis Version.

Delete

Use this command to delete an analysis from your directory and from your list of existing analyses. When you use this command, you will be prompted to identify the analysis that you want to delete. You will also be given an opportunity to confirm your selection.

Delete Results

Use this command to delete the results of an analysis from its database. This will reduce the size of the database. You should only use this command if you do not often refer to the results of this analysis, and are only archiving the analysis for reference purposes. If you want to view the results at some later point in time, you can always execute the operations and maintenance models again. This will re-generate the results, and re-populate your analysis database.

In the case of Advanced Workload missions, the results are not stored in the database. For this reason, deleting results will not reduce the database size. For more information, please see Advanced Workload Reports.

Print Setup

Use this option to set the default printer and change other printer options. You must have a default printer identified in order for the reports to be visible.

Import Analysis

Use this option to import an analysis and all of its data into your list of existing analyses. If that analysis was created in an older version of IMPRINT, then IMPRINT will

automatically translate that analysis into a format that is compatible with your version.

Export Analysis

Use this option to export an analysis and all of its data to another user or for archiving purposes. IMPRINT will save the file wherever you specify. The file format is an SQL database, so you will not be able to read the export file (extension IMP) with a text editor or word processor.

Import Advanced Mission

You can import advanced missions from the commercial WinCrew product into your open analysis in IMPRINT. To perform this capability, select “Import Advanced Mission” from the “File” menu. This menu item is available if you have an open analysis.

Export Advanced Mission

You can export advanced missions from your open analysis in IMPRINT to the commercial WinCrew product. To perform this capability, select “Export Advanced Mission” from the “File” menu. This menu item is available if you have an open analysis.

Import LSA File

You can use this utility to import Logistics Systems Analysis (LSA) Records into your open analysis. These records include maintenance data, broken out by subsystem and component.

IMPRINT accepts three different LSA formats. These include 750-16, 1388-2A and 1388-2B formats. The first two formats accept the data from the "02" report. The 1388-2B format accepts data from the "01" report. These are standard formats.

Before you import an LSA file, some preparation must be conducted. First, make sure your data are in ASCII text files. Most likely, you will receive your LSA report in a Word document. If this is the case, follow these steps before attempting to import the data:

1. Open the file in Word.
2. Select the entire file, and change the font to Times Roman, and the size to 6 point. This should remove the wrap-arounds from your data records. You do not need to make any other modifications to the file.
3. Save the file as a text file, with line breaks. Make sure the extension is *.txt.

Next, open the analysis in IMPRINT into which you want to import the data. If any equipment data exist for that analysis they will be REPLACED with the new records. Choose "Import LSA File" from the “File” menu in IMPRINT. You will be prompted to identify your LSA file. Browse to the place in your directory structure where you have

stored the *.txt file and select the file.

Next, IMPRINT will prompt you to identify the format of the file. Choose the correct format. The most common format is 1388-2B.

Now, IMPRINT will ask you to identify whether you want to filter any of the LSA records. You can specify that records which have a small estimated maintenance man-hour requirement not be imported into your database. This will make your analysis more efficient. The default filter value is .10 annual maintenance man-hours. Any records that are filtered will be stored in a text file in your IMPRINT directory named "filtered.txt." You can review the filtered records at your leisure.

As IMPRINT imports your data, it may ask you questions. For example, it is common for LSA data sets to be of an inconsistent quality. It is common for there to be duplicate records for the same component and repair task. If IMPRINT identifies any duplicate records, it will ask you which record you would like to keep. You can tell IMPRINT to keep all duplicates. In that case, it will change the component name (by appending an alphanumeric (e.g., "- A" or "- B")) in order to ensure that all component names are unique. If IMPRINT identifies duplicate records that have different MOS', the records will be kept in your data set.

IMPRINT may also find MOS's that are in your LSA data but are not recognized by IMPRINT. Sometimes these MOS's are too new for IMPRINT. Sometimes they are used to identify civilians. In any case, if IMPRINT finds an MOS that it does not recognize, you will be prompted to assign it to an MOS from the library. Later, you can go into your data and review your reassigned tasks.

After the import is complete, you will have two new text files in your IMPRINT directory (in addition to filtered.txt, mentioned above). All data records that were successfully imported will be documented in "goodrecs.txt." All duplicated records that you chose to discard will be documented in "duplicat.txt." These files are provided for your records, and are not needed by IMPRINT.

Now, you will be able to review and edit the data that have been imported into IMPRINT. You will find your data under the "Define Equipment" option.

Edit Menu

Duplicate

You should use this command to copy data into your open analysis from any other existing analysis in your list. When you choose this option, you will be prompted to identify the existing analysis from which you wish to copy. You will notice that the analysis you have open will not be available in the list.

Once you have identified the analysis from which you want to copy, you will be able to

select any level of data, including mission and equipment data, from the hierarchy of existing data in your database.

Append Task Lists

Operator

You can use this option to bring maintenance task data into IMPRINT from an external text file.

To use this capability, choose “Append” from the “Edit” menu pull-down. From the cascading menu, select "Operator."

Next, IMPRINT will help you browse through your directory structure to find and select your import text file. Once you have found the file, double click on it to select it. IMPRINT will attempt to import the data.

The text file must be in a tab delimited ASCII format. The columns must be in the following order:

- Task Name
- Mean Time
- Mean Accuracy
- Accuracy Measure
- Operator Name

If you are attempting to paste data into IMPRINT, we recommend that you consider using the “Review Operator Tasks” option, under the “Options” menu.

Maintainer

You can use this option to bring maintenance task data into IMPRINT from an external text file.

To use this capability, choose “Append” from the “Edit” menu pull-down. From the cascading menu, select "Maintainer." Now, you will be provided with a list of the subsystems that are in the system you have open. Select a subsystem from this list into which you want to insert your maintenance tasks.

Next, IMPRINT will help you browse through your directory structure to find and select your import text file. Once you have found the file, double click on it to select it. IMPRINT will attempt to import the data.

The text file must be in a tab delimited ASCII format. The columns must be in the following order:

- Maintenance Action Name
- Component Name

If you are attempting to paste data into IMPRINT, we recommend that you consider using the “Review Maintainer Tasks” option, under the “Options” menu.

Notes

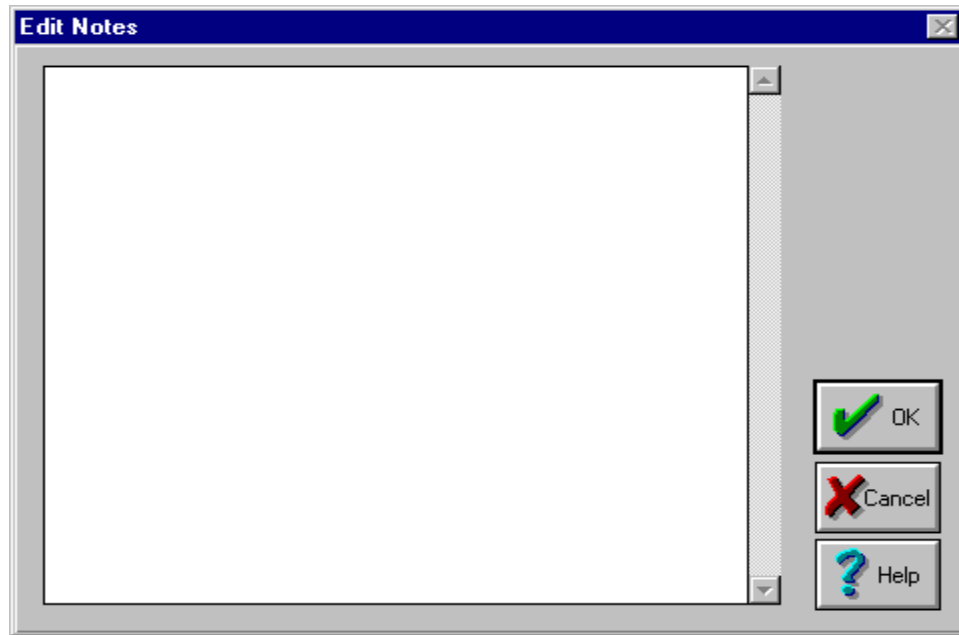


Figure 3-3. Edit Notes

Use this capability to document your assumptions about the analysis on which you are working. You can enter up to 1000 characters of text. You can also cut and paste text between the notes and the Windows clipboard. There is a single note for your analysis.

Define Menu

System Mission

IMPRINT allows you to analyze a new weapon system by helping you build models of each mission that the weapon system will be capable of accomplishing. Since it is typically easier to describe the mission by breaking it into smaller “sub” functions than trying to describe the mission as a whole, you build these models by breaking down the mission into a network of functions. Each of the functions is then further broken down into a network consisting of other functions and tasks.

Then, by executing the mission model simulation, you can study the range of results that occur in the mission. A description of the variability of each element can be obtained for further analysis.

IMPRINT performs the simulation analysis based on how long you tell it to perform each task in the mission. Also with each task, you estimate accuracy levels and assign workload values that reflect the amount of effort the crew member will have to expend to

perform the task. During the simulation, IMPRINT predicts task performance and calculates how much workload each crew member was experiencing throughout the mission. In this way you determine whether the crew members were overloaded, and if so, how changes can be made to reduce his workload to an acceptable level.

At the completion of the simulation, IMPRINT can compare the minimum acceptable mission performance time and accuracy to the predicted performance. This will determine whether the mission met its performance requirements.

If you are interested in predicting the workload associated with your mission, you can evaluate workload using either the Visual, Auditory, Cognitive, and Psychomotor (VACP) method or the Advanced Workload method. The VACP method is the simpler method and is intended to be used early in your design process. The Advanced Workload method provides a much more detailed look at the workload issue and enables you to examine the impact of workload management strategies. We recommend that you begin by using the VACP method, and if necessary, apply the Advanced Workload method as your analysis matures. When you change a mission from one method to the other, using the radio button at the bottom of the Define Mission dialog, all your data will be preserved and applied to the other analysis.

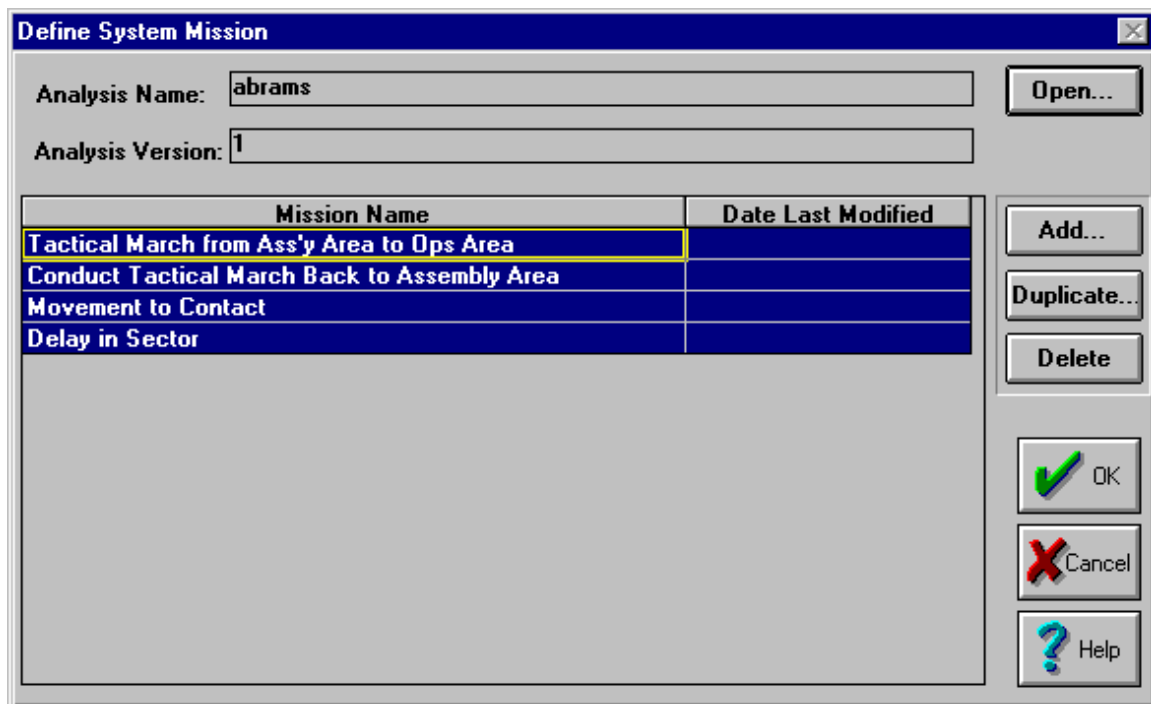


Figure 3-4. Define System Mission

To begin developing a description of the operational system missions, choose the “System Mission...” option from the “Define” menu. When you make this menu selection, IMPRINT will display a list of the missions currently in the working database

for the system you selected. This list also includes the date you last made changes to each of the missions.

This dialog box includes buttons that enable you to open an existing mission, add a new mission to the list, delete the highlighted mission, or make a duplicate of the highlighted mission. To select a mission and open it, highlight it using the mouse, and click on the "Open..." button. Adding, deleting and duplicating can be performed in a similar manner.

IMPRINT allows you to analyze the performance (i.e., time, accuracy, and workload) of a new weapon system by helping you build models of each mission that the weapon system will be capable of accomplishing.

Duplicate Button

Clicking on the Duplicate button will duplicate the mission (and all its associated data) that is highlighted in the "Mission Name" text box.

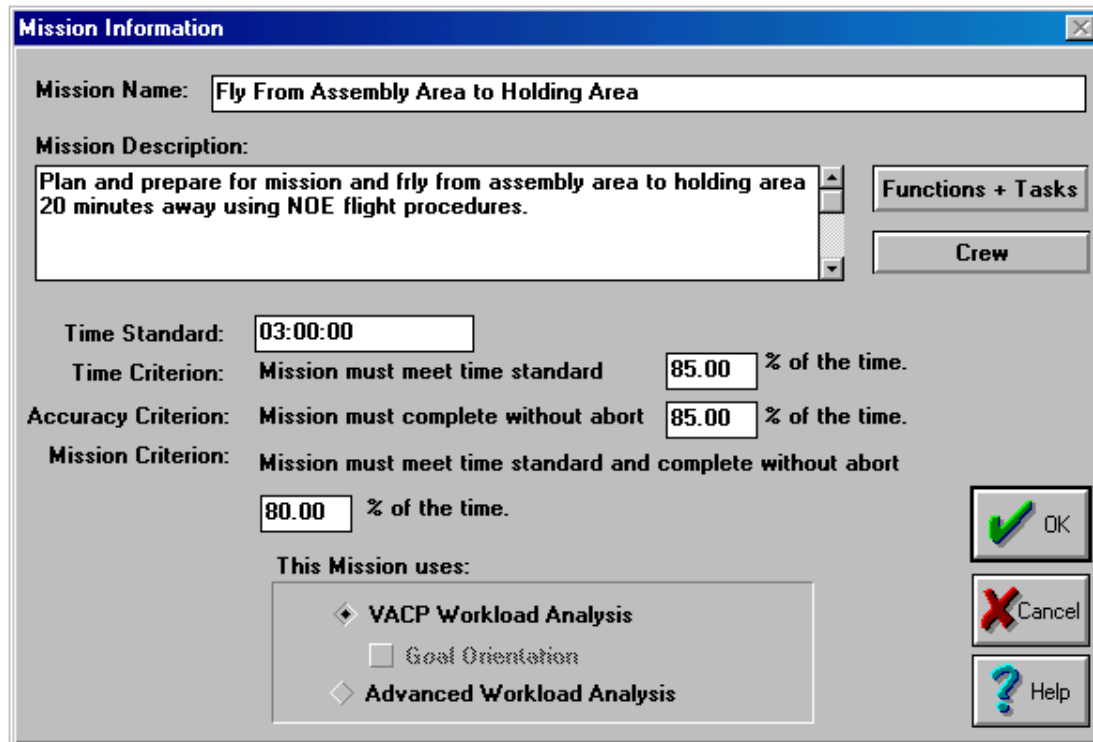
Delete Button

Clicking on the Delete button will delete the mission (and all its associated data) that is highlighted in the "Mission Name" text box.

Add Button

Clicking on this button allows you to add a new operational mission to this analysis. If you select this option, be advised that initially the mission will have a name only and no associated data (such as functions and tasks). You can copy functions and tasks from other analyses to the mission by using the "duplicate" option under the "Edit" selection from the main menu.

After you add a mission, you will get the following screen with only default data filled in. When you open an existing mission, you will get a screen like the following one, with the data you'd entered previously.



Mission Information

Mission Name: Fly From Assembly Area to Holding Area

Mission Description:
Plan and prepare for mission and fly from assembly area to holding area 20 minutes away using NOE flight procedures.

Functions + Tasks

Crew

Time Standard: 03:00:00

Time Criterion: Mission must meet time standard 85.00 % of the time.

Accuracy Criterion: Mission must complete without abort 85.00 % of the time.

Mission Criterion: Mission must meet time standard and complete without abort 80.00 % of the time.

This Mission uses:

- ☒ VACP Workload Analysis
- ☐ Goal Orientation
- ☒ Advanced Workload Analysis

OK **Cancel** **Help**

Figure 3-5. Mission Information

The Mission Information dialog box contains several data elements that correspond to the mission that you have selected. At the top of the dialog box is the Mission Name. To change the Mission Name, type over the existing text in the text box. The next data element is the Mission Description, which includes a textual description of the mission. The next data element is the Mission Time Standard. This time standard is the maximum acceptable time by which the mission must be performed in order to be considered a success. The Mission Time Criterion is the percentage of mission runs that must be performed within the mission time standard. Since the elements of the mission are variable, the predicted mission performance will also vary. The criterion allows you to account for this, and gives you an opportunity to specify a realistic percentage of runs that must meet the standards.

The next data element is the Mission Accuracy Criterion. At the task level, an accuracy failure can lead to mission abort. The Mission Accuracy Criterion lets you specify the percentage of time that the mission must complete without an abort. The final data element is the Mission Criterion. This is a percentage that represents how often the mission must meet both its time and accuracy standards at the same time. Once in a while, your mission may be able to miss either the time or accuracy standard, but here you define how often it must meet both.

Later, you can execute a simulation model of your mission. The results of that mission model will be compared to the standards and criteria you enter here. In the reports you will receive a summary of how many times the standards and criteria were met.

To change the values in this dialog box, use the mouse to position the cursor in the box you want to change. Click once to set the cursor in the box, and then type in the new value. The format for the time value is hh:mm:ss.00, and the colons are required. Notice that you can enter hundredths of a second after the decimal point.

Functions + Tasks Button

To develop a description of the functions and tasks that make up your mission, choose the “Functions + Tasks” button from the Mission Information dialog box. When you make this selection, IMPRINT will display a list of the functions and tasks currently in the first level of the mission you selected. The name of the Mission you have selected and the Function name are displayed near the top of the dialog box. This list includes an indication of the name of each node and whether each node is a function or a task.

Crew Button

Clicking this button displays a list of the crew members for the selected mission. The interface you see varies depending upon whether you are working on an Advanced or VACP mission. More information regarding the data needed are provided later in this chapter, under the “Crew” topic.

VACP versus Advanced Workload Mission Radio Button

In IMPRINT, you can analyze the workload of operational mission performance in two ways. You can use the VACP (Visual, Auditory, Cognitive, and Psychomotor) method of analyzing workload, or you can use the Advanced Workload capability.

The VACP analysis contains a fairly simple version of workload analysis in which workload is estimated by task for each of the four "channels" (i.e., Visual, Auditory, Cognitive, and Psychomotor). Then, as the model runs, workload is summed across tasks, within channels for each operator. At the conclusion of the run, you can see the value of workload versus time and can use this to identify "peaks" during your operational mission. You would then use the outputs of IMPRINT to establish which tasks were being performed during those peaks. These tasks would be candidates for reassignment or redesign.

The Advanced Workload capability contains an implementation of workload modeling according to Chris Wickens' Multiple Resource Theory. This enables you to evaluate crew workload in a very detailed manner. It also enables you to consider the impact of conflicting human resources, and the ways in which crew members will attempt to dynamically manage their workload. This capability was first provided in a tool developed by the Army's Human Engineering Laboratory, named CREWCUT. Later, it was moved to the Microsoft Windows environment, and was named WinCrew. The WinCrew functionality has been embedded in IMPRINT. For more information regarding the theoretical foundation of these products, we recommend that you read the technical documentation produced for the CREWCUT project. For a copy of this documentation, contact Mr. John Lockett at the Army Research Laboratory Human

Research and Engineering Directorate (jlockett@arl.mil).

IMPRINT enables you to switch missions back and forth between a VACP analysis and an Advanced Workload analysis. You can make this switch by changing the selection on the radio button at the bottom of the Mission Selection dialog. When you switch the setting of the radio button, all your previously entered data will still be accessible and will be applied to the appropriate data items. In this way, you can switch a mission back and forth without losing any data.

Function and Task List

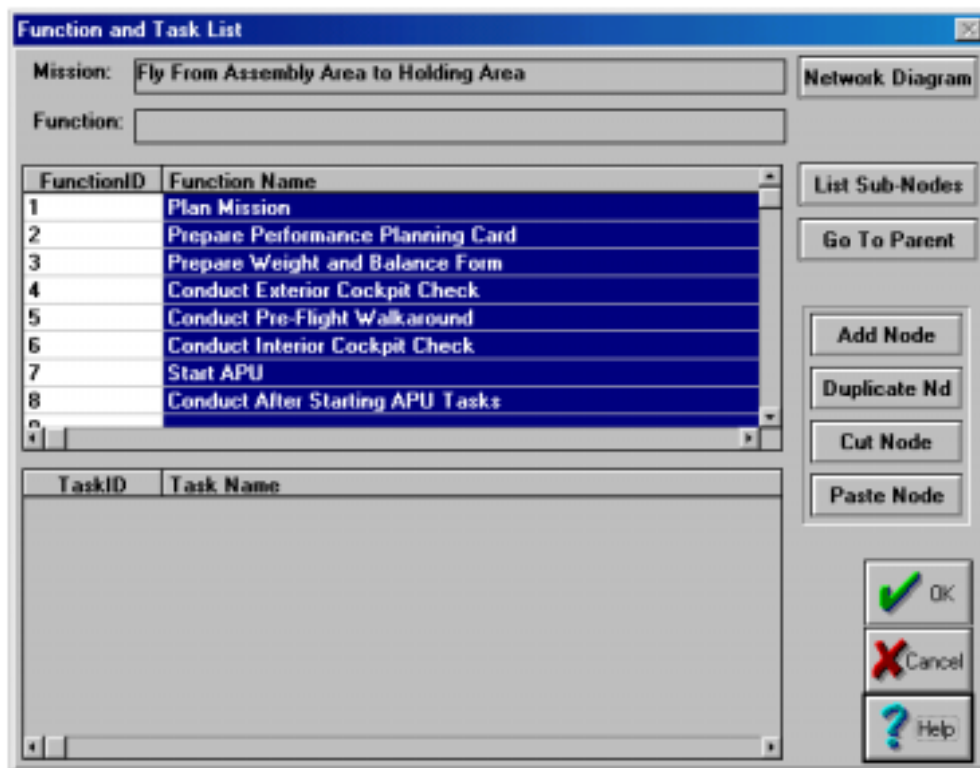


Figure 3-6. Function and Task List

To develop a description of the functions and tasks that make up your mission, choose the “Functions + Tasks” button from the Mission Information dialog box. When you make this selection, IMPRINT will display a list of the functions and tasks currently in the first level of the mission you selected. The name of the Mission you have selected and the Function name are displayed near the top of the dialog box. This list includes an indication of the name of each node and whether each node is a function or a task.

Also, you will see that the leftmost column of the list is an ID. You can edit these ID's to change the numbers of the nodes in your mission network diagram. If you do edit these values, IMPRINT has to go through all of your mission data and update all references to this node. This can take some time if you have a large mission. Also, these ID's are not related to the sequence of your functions and tasks. All sequencing is determined by the

paths you draw between the nodes. The ID numbers are purely for labeling purposes.

This dialog box includes buttons along the right edge of the dialog box that enable you to: add, duplicate, cut and paste new nodes in your network. To see the Network Diagram for this mission click on the “Network Diagram” button. Selecting the “List Members” button will list the functions and tasks that are members of the highlighted function. If you have highlighted a task, the “List Members” button will have no effect.

Add Node Button

To add a node, click on the “Add Node” button. You will get a prompt that lets you add either a function or a task to this level of your network.

Duplicate Nd Button

To duplicate a node, highlight the node you want to copy and click on the “Duplicate Nd” button. You can then use the “Paste Node” button to paste the duplicated node into any level of the mission network.

Cut Node Button

To delete a node, highlight the node and click on the “Cut Node” button. You can then use the “Paste Node” button to paste the deleted node into any level of the mission network.

Paste Node Button

The “Paste Node” button is used in conjunction with either the “Duplicate Nd” button or the “Cut Node” button. You can click in the function or task list at any level of the mission network, and then click on the “Paste Node” button to paste the duplicated or deleted node. You can use the “Paste Node” button more than once to paste in as many copies of the node as you want.

Network Diagram Button

Clicking this button will take you to the network diagram that enables you to develop a graphical drawing of how the functions and tasks in your operational mission are related to one another. It is also from this diagram that you enter the data that controls the execution of your model. To enter the data, you use the select tool at the top left of the diagram tool bar and double click on the network element for which you want to enter data.

List Sub-Nodes Button

To develop a description of the functions and tasks that make up your mission, choose the “List Sub-Nodes” option from the Function and Task List dialog box. When you make this selection, IMPRINT will display a list of the functions and tasks currently in the mission you selected. The name of the Mission you have selected and the Function name are displayed near the top of the dialog box. This list includes an indication of the name of each node and whether each node is a function or a task.

This dialog box includes buttons along the right edge of the dialog box that enable you to: add, duplicate, cut, and paste new nodes in your network. To see the Network Diagram for this mission click on the “Network Diagram” button.

Go To Parent Button

When you click this button the parent node of the lower level node(s) highlighted will be displayed.

Network Diagram

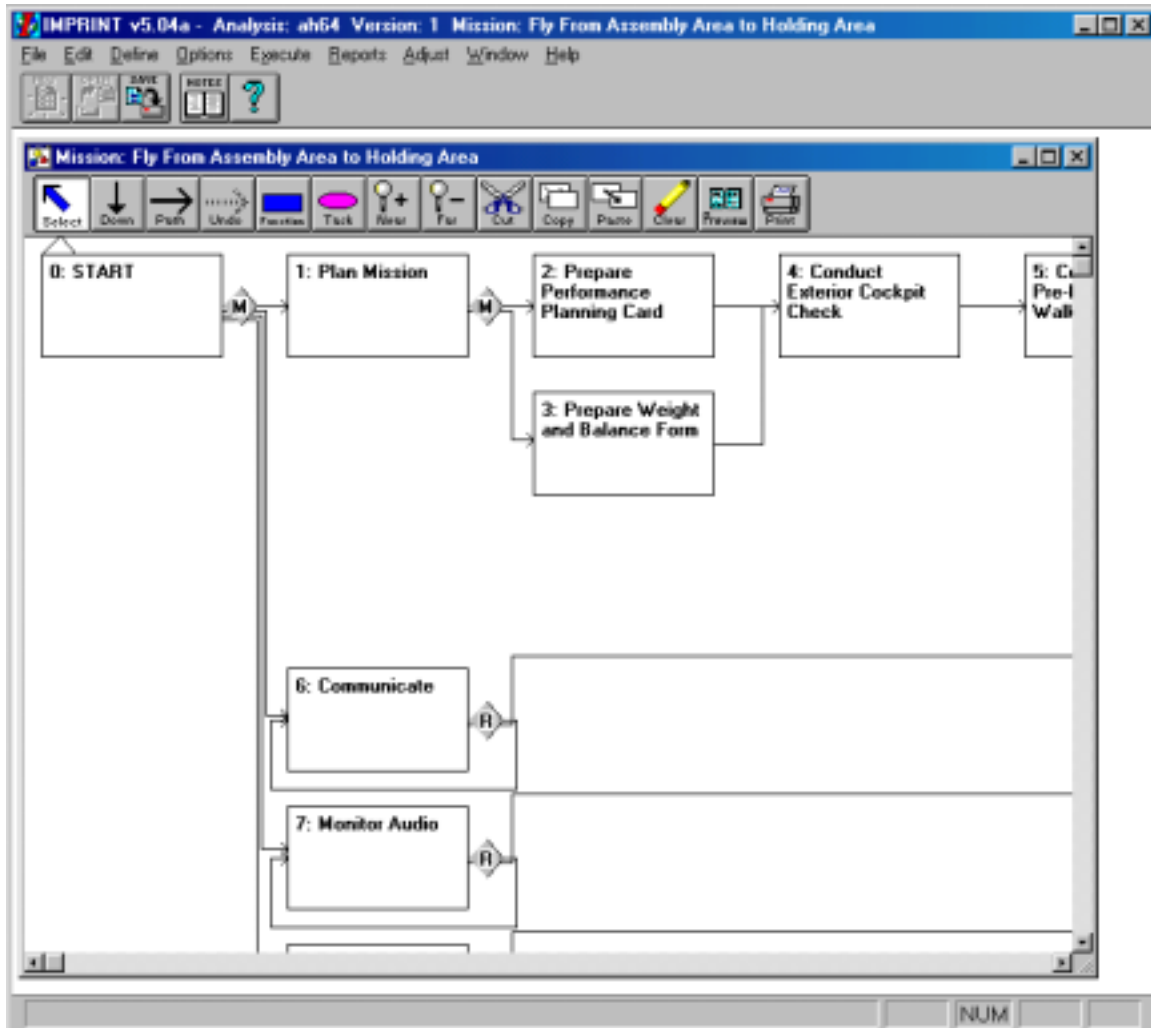


Figure 3-7. Network Diagram

The network diagram enables you to develop a graphical drawing of how the functions and tasks in your operational mission are related to one another. At the top of the drawing is the Diagram Tool bar. This tool bar is used to place and move functions and tasks on the network diagram, and to specify the paths that connect them to each other.

It is also from this diagram that you enter the data that controls the execution of your model. To enter the data, you use the select tool at the top left of the diagram tool bar and double click on the network element for which you want to enter data.

You will notice that the network diagram scrolls both horizontally and vertically, enabling you to enter quite large networks. We recommend that you try to use hierarchical decomposition techniques to keep each network to a reasonable size. In IMPRINT, missions are composed of functions and tasks, and each function is itself composed of a network of tasks and functions.

When you draw paths between nodes on the network diagram, you will begin the process of identifying a decision type for each of the nodes in your network. If you draw more than one path from a node, a decision diamond will display. If you double click on the decision diamond, you will see the interface shown below.

Figure 3-8. Task Branching Logic

The possible decision types are as follows:

- Single - The same node always follows this one.
- Multiple - More than one node will begin as soon as this one is completed. All following nodes will begin performing at the same time. You must specify a Rejoin Node for all multiple decisions.
- Probabilistic - More than one node will follow this one. Each

following node has a probability of being selected. The sum of the probabilities must equal 100 percent.

- Repeating - This node will repeat itself before going on to its following node. There are three types of repeating nodes. You can select whether the node repeats a specific number of times, or whether it repeats until the clock reaches a specific time, or whether it repeats until the simulation ends. To specify a repeating decision type, you must draw a single path from the node back to itself, and one path to the node that will follow it once the repeating is complete (often, this will be the “END” node)
- Tactical - This decision type is only available if you are defining an Advanced Mission. Any task with a tactical decision type causes one of the following tasks to execute at the completion of the lead task. The tactical expressions that you enter are used to determine which of the potential following tasks will be executed. The task whose tactical expression evaluates to the greatest value will follow the source task. If multiple following tasks have equal high tactical expression values, the first task listed will execute next.

Diagram Tool Bar

At the top of each IMPRINT network diagram window is a tool bar. Fourteen tools reside in the tool bar; each is represented by an icon and a label.

The first icon is an arrow pointing to the upper left corner of the window. This is the select tool. When you click on this tool, and then click on an element in the diagram, the element will be selected. Selection is indicated by the element being highlighted. It can then be deleted, copied, etc. To open a network element, use the selection tool and double click.

The next icon is the down icon. This is represented by an arrow pointing down with horizontal crosshatches. This tool lets you go “down” into a function and open the child function’s network of tasks and functions. You cannot go “down” into a task since tasks are terminal nodes and have no networks in them. Also, you cannot go down into a START or END function.

If you have gone “down” into a function, next is the up icon. This is represented by an arrow pointing up. Corresponding with the down tool, the up tool takes you to the parent function for the network currently displayed.

The path tool, represented by a right pointing arrow, is used to draw branches or paths between the nodes in your diagram. These nodes can be a mixture of functions and tasks. To draw a path, put the tool on the node you want to draw the path from and click. Hold the mouse button down while you drag the cursor to the node you want to draw the path to and then release the mouse button. If you draw more than one path from the same node, a decision diamond will automatically appear on your network diagram. Use the

select tool and double click on the decision diamond to specify the branching logic associated with the multiple paths.

To delete a path on your diagram, use the undo tool. The undo icon appears as a right pointing arrow made up of dotted lines. Follow the same procedure as with the path tool, and re-trace the path you want to erase.

The function tool, a rectangular icon, will add a function to your network. Just place the tool on the diagram at the place that you want the new rectangular function to be placed and click once. IMPRINT will not let you place a function on top of another network element.

The task tool, an oval shaped icon, works similarly to the function tool. Place the tool on the diagram at the place that you want to new task to occupy and click once. IMPRINT will not let you place a task on top of another network element.

The next two tools, a magnifying glass and a telescope, let you zoom in and out of the network diagram. Select the tool and click on the network diagram. It will zoom in and out of the diagram view, letting you see more or less detail as it zooms.

The next four icons represent edit functions. The first tool, the scissors, is used to cut a highlighted function or task and place it on the clipboard. It can then be pasted to another area of the network.

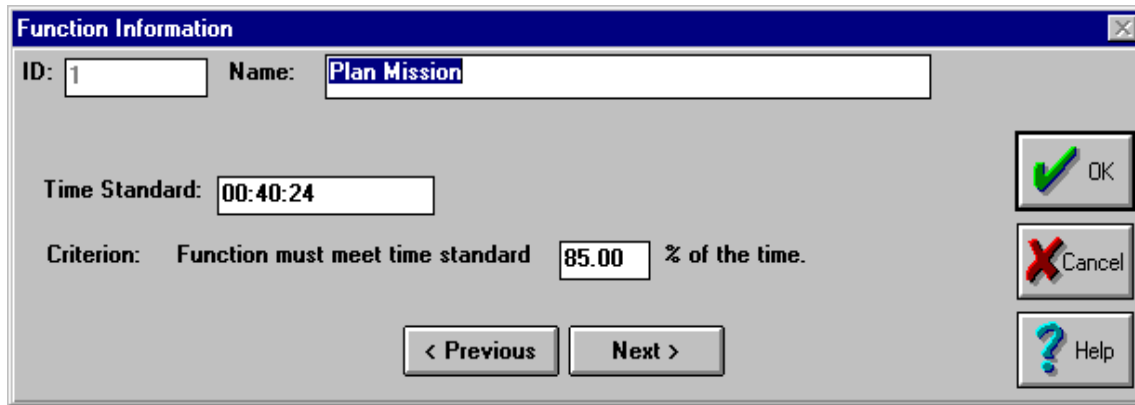
The second tool, shown as two documents with an arrow between them, is used to copy a highlighted function or task and to put a copy on the clipboard so that it can be pasted elsewhere in your network.

The third tool is the paste tool, and is used to copy the data currently on the clipboard to the current cursor position.

The fourth tool, shown as a pencil eraser, is used to clear a network function or task. Data that are "cleared" cannot be pasted elsewhere in a network.

Function Information

IMPRINT helps you break the mission down into its functions. Examples of functions are "Acquire Target," "Engage Target" and "Communicate." Also, IMPRINT helps you identify maximum acceptable performance times for each function. Finally, IMPRINT helps you link the functions together in a network that makes up the mission.



The dialog box titled "Function Information" contains the following fields and controls:

- ID:** A text box containing the value "1".
- Name:** A text box containing the value "Plan Mission".
- Time Standard:** A text box containing the value "00:40:24".
- Criterion:** A label followed by the text "Function must meet time standard", a text box containing "85.00", and the text "% of the time.".
- Navigation Buttons:** "< Previous" and "Next >" buttons at the bottom center.
- Action Buttons:** "OK" (with a green checkmark icon), "Cancel" (with a red X icon), and "Help" (with a blue question mark icon) buttons on the right side.

Figure 3-9. Function Information

The Function Information dialog box contains three data elements. The first is the Function Name. This is a short description of the function, and is the label that is written into the node when the Network Diagram is displayed. The second data element is the Function Time Standard. This value is the maximum acceptable performance time for this function. The final data element is the Function Criterion. This value is the percentage of times that this function must meet its time standard to be considered successful.

To change the values in this dialog box, use the mouse to position the cursor in the box you want to change. Click once to set the cursor in the box, and then type in the new value. The format for the time value is hh:mm:ss.00, and the colons are required. Notice that you can enter hundredths of a second after the decimal point.

The ID for the function is also displayed on this dialog, however you must return to the function and task list if you want to change the ID. Remember that the ID's do not affect sequence, and are merely task label information. Sequence is solely determined by that paths you draw between nodes.

The "Next" and "Previous" buttons enable you to page forward and backward through the elements on the dialog box. For example, if you click on the "Next" button at the bottom of the dialog box, you will move forward one element and the information for that element will be displayed. These buttons are provided on several dialog boxes, and are intended to enable you to move through data elements more quickly and efficiently.

Task Information

IMPRINT helps you break the mission down into its' basic tasks. Examples of tasks are "Tune Radio," "Push Button" and "Clear Cannon." Also, IMPRINT helps you enter the relevant data elements for each task. Finally, it helps you link the tasks together in a network that makes up the mission.

The Task Information dialog box contains many data elements, and is grouped into areas that contain related information. Notice that there are tabs at the bottom of the Task Information dialog box that allow you to display Timing & Accuracy information, Effects

information, Failure Consequences information, Workload information, Crew Assignment information, and finally, Taxon assignments.

At the top of each tab on the dialog box, you will see the Task Name. This is a short description of the task and is the label written in the node when the Network Diagram is displayed.

When you first enter this dialog box, you will see either the last information sheet you were in this task or the default Timing and Accuracy information sheet. To change the type of data shown, click on the appropriate tab at the bottom of the screen. To move through the task list without returning to the network diagram, use the Previous and Next buttons at the bottom of the dialog box.

To change the values in this dialog box, use the mouse to position the cursor in the box you want to change. Click once to set the cursor in the box, and then type in the new value. The format for the time values is hh:mm:ss.00, and the colons are required. Notice that you can enter hundredths of a second after the decimal point.

The ID for the task is also displayed on this dialog, however you must return to the function and task list if you want to change the ID. Remember that the ID's do not affect sequence, and are merely task label information. Sequence is solely determined by that paths you draw between nodes.

Time and Accuracy

Task Information

ID: Name:

Time Standard:

Accuracy Standard: Accuracy Measure:

Criterion: Task must meet Time Standard AND Accuracy Standard % of the time

Estimated Task Time:

Mean Time: Time StDev:

Distribution:

Estimated Task Accuracy:

Mean Accuracy: Accuracy Standard Deviation:

Probability of Success: %

Buttons: < Previous, Next >, OK, Cancel, Calculate, Draw, Micromodels...

Tabs: Time&Acc, Effects, Failure, Workload, Crew Assgn., Taxon

Figure 3-10. Task Information Time & Accuracy Tab

Beginning at the top of the dialog box under the task name, the first group of data displayed includes the performance standards for this task. These values define how well the task needs to be performed to be considered successful. The Task Time Standard is the maximum acceptable performance time for this task. The Task Accuracy Description is entered in two parts, a numerical part and an accuracy measure. Together, these values specify how well the task must be performed. The third data element is the Task Criterion. This value is the percentage of times that this task must meet both the time standard and the accuracy standard in the same occurrence to be considered successful.

When IMPRINT executes your mission model, the Estimated Task Mean Time, Standard Deviation, and Distribution are used to choose a specific task time for each occurrence of each tasks. These times are then accumulated throughout the model run and compared to the time standard in order to report the percentage of successes for each task. Similarly, the Probability of Success (calculated based on the Accuracy Mean, Accuracy Standard Deviation, and Accuracy Standard) is used to determine whether the task has succeeded or failed each time it occurs. These successes and failures are then accumulated throughout the model run in order to report the percentage of accuracy successes for each task.

The second group of data elements on this screen is three elements that describe the estimated task time. These values specify your best estimate for describing the distribution of the length of time that the task will be performed in a real environment. The first data element in this group is the Mean Time. The mean time is your estimate of the most likely, or average, task performance time. Next, you will enter the Standard Deviation. The standard deviation describes the average amount of deviation from the mean in which this task is likely to be performed. Finally, you can select a Distribution. The distribution describes the statistical distribution properties from which the actual occurrence time will be drawn. (If you are unfamiliar with statistical distributions, we recommend that you consult a statistics textbook or someone more knowledgeable in this field.) You can also access Micromodels of human performance data using the "Micromodels" button on this screen. The remainder of the information on this screen relates to the probability that this task will actually be performed to the standard specified by the Accuracy Description.

In IMPRINT, you specify the likelihood that a task will be performed accurately by entering the estimated mean and standard deviation that work together with the accuracy measure (e.g., "percent steps correct"). When the model runs, IMPRINT pulls a number from a normal distribution created with the mean and standard deviation you enter. This is compared to the accuracy standard to determine whether the task succeeded or failed accuracy on each occurrence.

For example, you might say that on the average when performing this task the operators get 90 percent of the steps correct or for another tasks, they are within 10 mils of the correct azimuth. Under the first option, you will also specify the standard deviation, which in some sense is a measure of the worst and best the task is likely to be performed.

An easy rule of thumb for specifying the standard deviation is to compute the difference between the worst and best performance and divide it by 6. For example, if the worst performance is 40% steps correct and the best is 100%, then an estimate for the standard deviation would be 10% ($((100 - 40)/6) = 10$).

We realize that it is often difficult for users to think of accuracy in these terms, and that it is often easier to think of it in terms of the probability of success. To accommodate this fact, we have provided a "Calculate" button that you can use to calculate the probability of success from the information you have entered. When you press the Calculate button, IMPRINT uses your accuracy mean and accuracy standard deviation, as well as the accuracy standard to calculate the probability of success. This is actually calculated using standard statistical procedures that compute the area under a Normal statistical curve. IMPRINT is also careful to evaluate your accuracy measure to determine whether "bigger values" are better (e.g., percent steps correct), or "smaller values" are better (e.g., miles from desired). For more information, please refer to a statistical textbook.

We have also provided access to a job aid through the Draw button on this screen. This button opens a dialog box that lets you enter three of the four data elements that are needed to specify accuracy (i.e., accuracy standard, accuracy mean, accuracy standard deviation, and probability of success), and it will calculate and display the fourth data item. Also, it will draw the normal distribution and show the area under the curve that is used to calculate the probability of success.

To change the values in this dialog box, use the mouse to position the cursor in the box you want to change. Click once to set the cursor in the box, and then type in the new value. The format for the time values is hh:mm:ss.00, and the colons are required. Notice that you can enter hundredths of a second after the decimal point.

MicroModel Button

Click on this button to get help in estimating a task mean time. Detailed "Micromodels" are provided to help construct an overall task time. These "Micromodels" provide time estimates for performing basic activities, such as visual scanning, moving a hand from one position to another, or pushing a button. By stringing together basic activities, an overall task time (or mean task time) can be estimated.

Draw Button

We have provided access to a job aid through the Draw button on this screen. This button opens a dialog box that lets you enter three of the four data elements that are needed to specify accuracy (i.e., accuracy standard, accuracy mean, accuracy standard deviation, and probability of success), and it will calculate and display the fourth data item. Also, it will draw the normal distribution and show the area under the curve that is used to calculate the probability of success.

Calculate Button

The calculate button uses the accuracy standard, the accuracy measure, the accuracy

mean, and the accuracy standard deviation that you have entered on this screen to calculate and display the probability of task success.

Advanced Mean Time

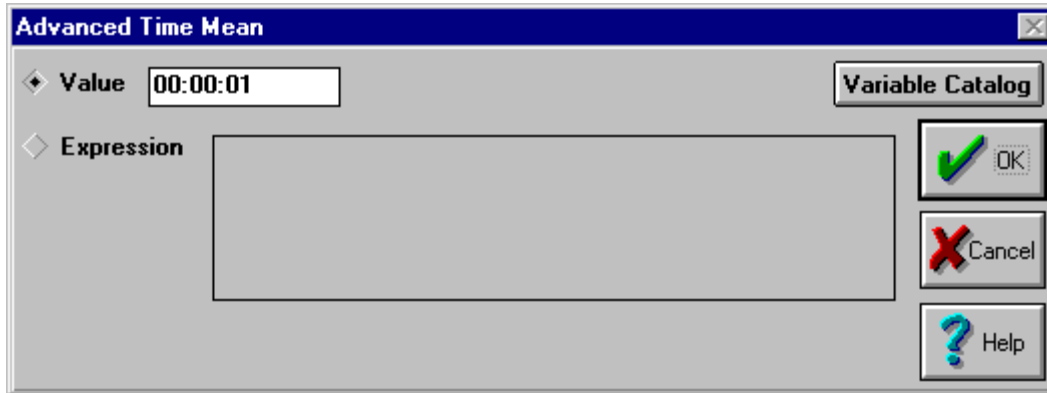


Figure 3-11. Advanced Mean Time

Each task in the mission has an estimated performance time associated with it. The performance time is determined from the time distribution, mean time, and standard deviation as specified on this dialog. The more accurately you estimate the mean times and standard deviations for the tasks, the more accurately the model will reflect actual performance and the more reliable is the resulting data.

The mean time represents the average number of seconds required to execute a task. You can either enter a mean time value (30;) or, if you are defining an Advanced Workload Mission, you can enter a mean time expression (e.g., if clock<=30 then 10 else 15;). Each expression is delimited by semicolons. In building the expressions, you can use any of the algebraic or logical operators, including the following: (&, |, >, <, :=, ==, +, -, *, and /) and you can use if-then-else statements. The assignment operator is :=. The equivalence operator is ==. You also have access to "micromodels" that will help you estimate human performance times. The purpose of the Micromodels are to utilize known human performance rules, principles, and research findings to generate task mean times in cases where test data or subject-matter-expert derived data do not exist or are unavailable

Variable Catalog

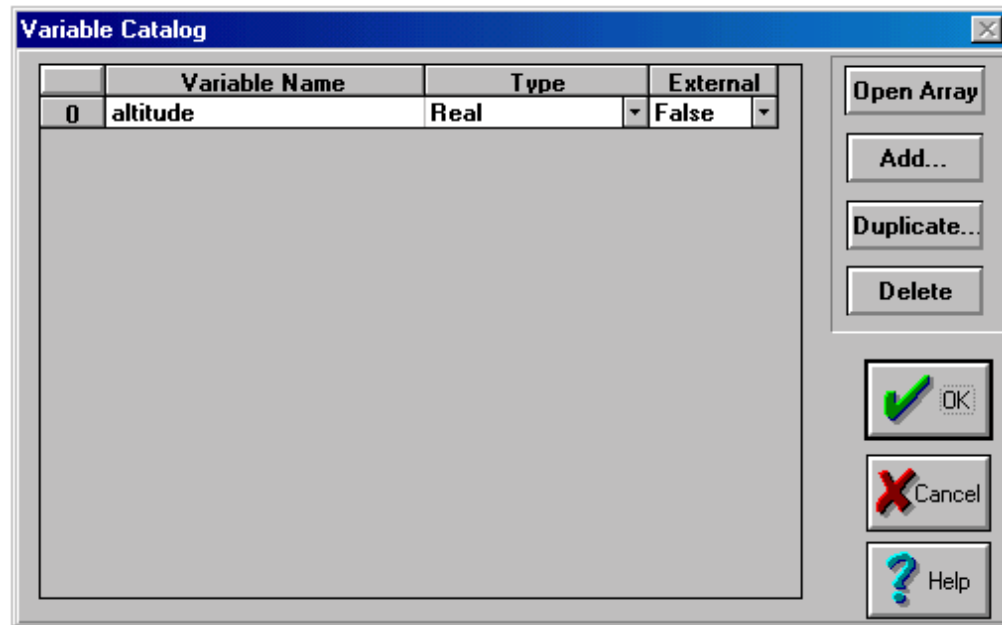


Figure 3-12. Variable Catalog

This capability is only available if you are working on an Advanced Mission. To view the variables click on the “Variable Catalog” button from the task branch dialog box or from the task description dialog box. To create a new variable, click on the “Add” button from the Variable Catalog window, enter a name for the variable, and select the variable type from the drop down box.

Add Variables Button

To create a new variable, click on the Add button from the Variable Catalog window, enter a name for the variable, and select the variable type.

The available variable types are:

- Real - contains a real number value and displays digits to the right of the decimal point
- Integer - contains an integer value
- Array of Reals - a one, two, or three-dimensional array with elements of the array containing real numbers
- Array of Integers - a one, two, or three-dimensional array with elements of the array containing integer numbers

To set the variable type, click in the variable type field then select the desired type. If you assign a variable as being an array (either real or integer), set the dimensions by clicking on the “Open Array” button. You can then change the range of each array dimensions by clicking on the appropriate dimension. You can have up to 32000 elements in each array dimensions.

Micromodels

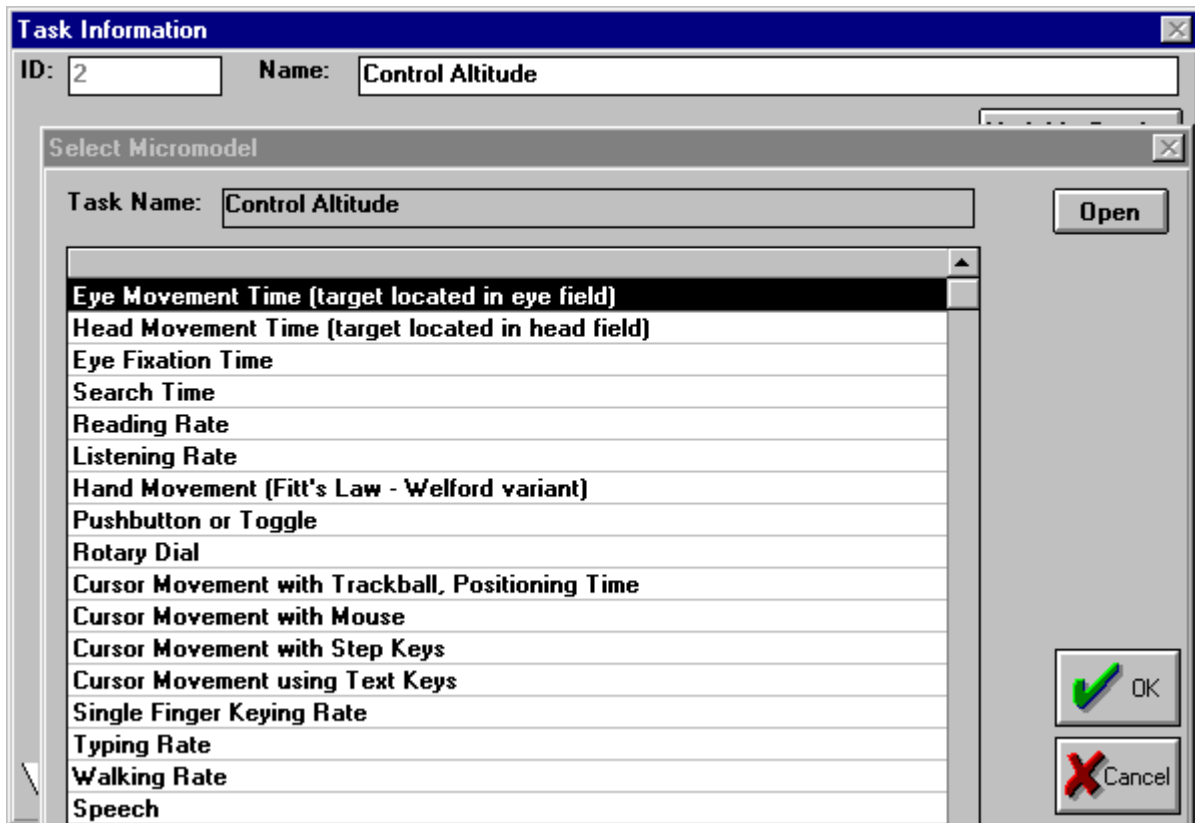


Figure 3-13. Micro Models

This capability provides access to a set of micromodels of human performance that have been gathered from the literature. Many of these micromodels are just constant values (e.g., Eye Movement Time (target is in the field)). Other micromodels include prompts for you to enter pertinent data. For example, in the Hand Movement micromodel, you enter distance to target and target size.

These micromodels are included in IMPRINT so that you can access them in order to help generate a task time estimate. The reference for each micromodel is included on the dialog, so that you can refer to the literature if you have specific questions about the assumptions behind each micromodel.

To select a micromodel, highlight it and press the Open button. You will be prompted to enter any parameter information that is needed. You can also see the reference for the micromodel at that time. A list of all the micromodels and their references is provided as an Appendix to this User Guide.

Effects

Task Information

ID: Name:

Task Priority: Interrupt Strategy: [Variable Catalog](#)

Release Condition

Beginning Effect

Ending Effect

[TaskID](#)
[< Previous](#)
[Next >](#)
☒ OK
☒ Cancel
☒ Help

[Time&Acc](#) [Effects](#) [Failure](#) [Workload](#) [Crew Assgn.](#) [Taxon](#)

Figure 3-14. Task Information Effects Tab

This dialog is only available if you have chosen an Advanced Mission. In this dialog, you can enter algebraic or logical expressions in your task's Release Condition, Beginning Effect, and Ending Effect. You can also enter the task's priority and interrupt strategy.

Interrupt Strategy

The interrupt strategy is used to describe whether the task can be resumed after being interrupted or if it needs to be restarted. Tasks in the Resume category can "pick up where they left off." In contrast, tasks in the Restart category pay a time penalty for interruption. They must start over again. To change the interrupt strategy, double click on a task to open the task parameter window, click in the Resume/Restart field, and select either "Resume" or "Restart."

Task Priority

Task priorities are used to execute priority-based workload management strategies. The priorities range from 1 (very low) to 5 (very high). New tasks are assigned a priority level of 3 (medium). To change a priority level for a task, double click on a task to open the task parameter window, click in the Task priority field of the task and enter a priority value between 1 and 5, or click on the drop box in the task priority field and select a priority from the list.

Release Condition

Sometimes a mission contains tasks that you want to execute only under certain

conditions. For example, it would not make sense for a tank commander to issue a fire command while the loader is loading the ammunition - he must wait until the loading is complete. To ensure that tasks are released only when the state of system has reached an appropriate point or when required resources are available, you need to use a release condition. If you have used any multiple decision types in your Advanced Mission model, you will need to use Release Conditions, Beginning and Ending effects to rejoin the multiple paths at the proper point in the network.

Release Conditions are used to check the state of a system before a task executes and hold off on executing until a certain condition is met. A release condition is an expression that is equal to zero when the task is not available and has a non zero value when the task is available. In order to restrict the conditions under which a task can execute, a release condition must be defined. To restrict the task's availability, define a release condition that is non-zero only under the circumstances in which you want the task to execute.

Each release condition expression is delimited by semicolons. In building the expressions, you can use any of the algebraic or logical operators, including the following: &, |, >, <, :=, ==, +, -, *, and /. You can also use if-then-else and While-Do statements. The assignment operator is :=. The equivalence operator is ==.

Beginning Effect

Beginning and ending effects enable you to develop one or more expressions that change the values of variables in the model as a result of a task starting or ending. Each expression is delimited by semicolons. In building expressions you can use any of the algebraic or logical operators, including if-then-else, &, <,>, |, :=, ==, +, -, *, and /. The assignment operator is :=. The equivalence operator is ==.

You can use beginning and ending effects with tactical decision branching. When a task is specified as having more than one following tasks with a tactical decision type, tactical expressions are used to specify which route is taken. The variables in the tactical expressions can be assigned different values in beginning or ending effects of other tasks to establish the true condition for the tactical decision.

To set a beginning effect for a task, double click on the task, click on the Effects tab at the bottom of the task dialog, and enter the desired expression(s).

To set an ending effect for a task, double click on the task, click on the Effects tab at the bottom of the task dialog, and enter the desired expression(s).

You have access to the variable catalog to aid you in specifying any effects. To view the catalog, click on the "Variable Catalog" button.

Ending Effect

Beginning and ending effects enable you to develop one or more expressions that change the values of variables in the model as a result of a task starting or ending. Each

expression is delimited by semicolons. In building expressions you can use any of the algebraic or logical operators, including if-then-else, &, <,>, |, :=, ==, +, -, *, and /. The assignment operator is :=. The equivalence operator is ==.

You can use beginning and ending effects with tactical decision branching. When a task is specified as having more than one following tasks with a tactical decision type, tactical expressions are used to specify which route is taken. The variables in the tactical expressions can be assigned different values in beginning or ending effects of other tasks to establish the true condition for the tactical decision.

To set a beginning effect for a task, double click on the task, click on the Effects tab at the bottom of the task dialog, and enter the desired expression(s).

To set an ending effect for a task, double click on the task, click on the Effects tab at the bottom of the task dialog, and enter the desired expression(s).

You have access to the variable catalog to aid you in specifying any effects. To view the catalog, click on the “Variable Catalog” button.

Task ID Button

Use this button to find out the modeling identification number for any task in your network. If you want to use the Start, Stop or Resume functions that are available to you in the Advanced Workload modeling, the parameters to those functions are the task ID numbers. These numbers are assigned automatically by IMPRINT's modeling engine (Micro Saint) and are NOT the same as your IMPRINT task numbers.

Expressions

Each expression in your Advanced Mission model must end with a semi-colon and may include any of the following elements:

- constants
- variables
- mathematical operators
- assignment operator
- equivalence operator
- adjustment operators
- logical operators
- if-then-else statements
- while-do statements

Constants

A constant is a quantity with a fixed, unvarying value—generally a number. Often in an Advanced Workload model you supply expressions that are constants for numeric task descriptors such as the Advanced Mean Time, or for logical expressions that are always true (like the default Release Condition) or always false.

Constants are also often used in combination with variables and mathematical or logical operators. In the release condition, the value of a variable is typically compared with a constant. In the mean time, constant values are often multiplied by variable values as adjustments.

Examples of expressions that are constants:

```
{Release Condition}  
1;
```

```
{Mean Time}  
9;
```

Examples of expressions that contain constants:

```
{Release Condition}  
1;operators > 0;
```

```
{Mean Time}  
15 *(1 + ftg_factor);
```

Variables

A variable is a label of one to twelve alphanumeric characters that is assigned a numeric value (variable names are case sensitive, so name and NAME are considered to be different). You can change the value assigned to a variable at any time using the assignment operator ($:=$) or one of the adjustment operators ($+=$, $-=$, $*=$, $/=$). In the following example, the variable operators (representing the number of operators available to perform the task) decreases by one when the task starts and increases by one when it finishes. You can use a variable any place that you would use a constant in an expression.

```
{Beginning Effect}  
operators -= 1;   or   operators := operators - 1;
```

```
{Ending Effect}  
operators += 1;   or   operators := operators +1;
```

Mathematical Operators

You can use these operators to perform arithmetic operations on numeric values:

Symbol:	()
Purpose:	Grouped operations
Example:	$(2*3) + 1 = 7$ but $2 * (3+1) = 8$

Symbol:	^
---------	---

Purpose: Exponentiation
Example: $2^3 = 2*2*2 = 8$ and $8^{(1/3)} = 2$

Symbol: *
Purpose: Multiplication
Example: $2*3 = 6$

Symbol: /
Purpose: Division
Example: $6/2 = 3$

Symbol: %
Purpose: Remainder division
Example: $7 \% 2 = \text{remainder of } 7/2 = 1$

Symbol: -
Purpose: Subtraction
Example: $7 - 2 = 5$

Symbol: +
Purpose: Addition
Example: $5 + 2 = 7$

The order of precedence for these operations is from the top down, that is, exponentiation is performed before multiplication, etc.

To change the order in which operations are performed, use parentheses. Operations within parentheses are performed first. Inside parentheses, the usual order of operations is maintained. If you are unsure how IMPRINT evaluates the mathematical operators, use parentheses to clarify the order.

Assignment Operator

The assignment operator ($:=$) assigns the value on the right of the operator to the variable on the left of the operator. For example, the expression $a := 3$; assigns the value three to the variable a . It also returns the value three, which is non zero, so it would be considered a true statement if you used it as a logical condition. However, you would generally not want to use the assignment operator in a logical condition statement.

Be careful not to confuse the assignment operator with the logical equality operator ($==$). If you want to test for equality, use the logical equality operator ($==$). This returns a value of one if the value on the right of the operator equals the value on the left, and returns a value of zero if it does not.

$a := 3$; means set a equal to 3

`a == 3;` means “Does the value of a equal 3?”

Adjustment Operators

The adjustment operators adjust the value of a variable based on its current value and some other number. These operators provide a shorthand for expressions that require repeating the variable name and using the assignment operator, as shown in the following table. You can use either of these forms when you need to adjust the value of a variable.

Long form: `variable := variable + number;`
Short form: `variable += number;`
Example: `x += 2;`

Long form: `variable := variable - number;`
Short form: `variable -= number;`
Example: `x -= 2;`

Long form: `variable := variable * number;`
Short form: `variable *= number;`
Example: `x *= 2;`

Long form: `variable := variable / number;`
Short form: `variable /= number;`
Example: `x /= 2;`

Equivalence Operator

The equivalence operator (`==`) is used to compare two values for equality. It returns a value of one if the value on the right of the operator equals the value on the left, and returns a value of zero if it does not. Typically, you would use this operator as part of an "if-then-else" statement.

Be careful not to confuse the equivalence operator with the assignment operator. The assignment operator (`:=`) assigns the value on the right of the operator to the variable on the left of the operator. For example, the expression `a := 3;` assigns the value three to the variable `a`. It also returns the value three, which is non zero, so it would be considered a true statement if you used it as a logical condition. However, you would generally not want to use the assignment operator in a logical condition statement.

`a := 3;` means set a equal to 3

`a == 3;` means “Does the value of a equal 3?”

Logical Operators

Use logical operators to compare two numeric values or logical statements. The result is equal to one (e.g., `==1`) if the comparison is true or equal to zero (e.g., `==0`) if the comparison is false. Similarly, any non zero value is considered true and a zero value is

considered false.

If $a = .001$ and $b = 3$ (which means a and b are both true)

then these expressions are true: $a \leq b$; $a < b$; $a \neq b$; $a \& b$; $a | b$;

and these expressions are false: $a == b$; $a \geq b$; $a > b$;

Note: Be careful not to confuse the logical equality operator ($==$) with the assignment operator ($:=$). The assignment operator sets the variable to its left equal to the value to its right and returns this value.

Symbol	Comparison:
$==$	Logical equality
\leq	Less than or equal to
\geq	Greater than or equal to
\neq	Not equal to
$<$	Less than
$>$	Greater than
$\&$	Logical AND
$ $	Logical OR

If-Then-Else Statements

Sometimes in your models, you may want to perform certain expressions only under certain conditions. For these cases, IMPRINT provides the following statement:

if x then y else z ;

This statement establishes that if condition x is true, then perform expression y ; if condition x is not true, then perform expression z . The “else” portion of the statement is optional.

Example 1:

if $a + 3 == 5$
then $b := 1, c := 1$;

If the value of $a + 3$ is equal to 5, then assign the variables b and c a value of one.

Example 2:

If a then $b += 1$
else $b -= 1$;

If the value of a is non zero, add one to the current value of b; otherwise, subtract one from the current value of b.

Example 3:

```
If a < b then b
else a;
```

If the value of a is less than the value of b, then the value of b is returned. Otherwise, the value of a is returned.

While-do statements

You may want an expression repeated in your model as long as a condition is true. A while-do loop repeats an expression(s) as long as a particular condition is true. For this case, IMPRINT provides the following statement:

```
while x do y;
```

When a while-do statement is executed, IMPRINT first checks whether condition x is true; if so, it proceeds to execute expression or function y. Then, it checks x again; if x is still true, IMPRINT executes y again. This process continues until x becomes false.

When IMPRINT determines that x is false, it does not execute y again. The condition x should always be one that eventually becomes false; otherwise you have an infinite loop that does not stop processing.

Failure Consequences

The interface that you will see under the Failure Consequences tab is different, depending on the type of mission you are defining. The two figures below illustrate the different interfaces.

VACP Mission Interface:

Task Information

ID: Name:

1) Task is degraded %

☐ Time %

☐ Accuracy %

2) Task Follows %

3) Mission fails %

4) No effect %

Total Probability = %

Time&Acc Effects **Failure** Workload Crew Assgn. Taxon

< Previous

Next >

OK

Cancel

Help

Figure 3-15. VACP Mission Interface Failure Tab

Advanced Mission Interface:

Task Information

ID: Name:

1) Task is degraded %

☐ Time %

☐ Accuracy

2) Task Follows %

3) Mission fails %

4) No effect %

5) Operator assignment will change: %

Operator:

Task:

Total Probability = %

Time&Acc Effects **Failure** Workload Crew Assgn. Taxon

< Previous

Next >

OK

Cancel

Help

Figure 3-16. Advanced Mission Interface Failure Tab

IMPRINT provides several possible consequences of task failure due to accuracy from which you can choose. These include changing the following task, causing the mission to abort, having no effect, and changing the time or accuracy on another task. If you are modeling an Advanced Mission, you will also have access to a consequence that changes the operator assigned to a task. You can assign probabilities to each of these consequences. When IMPRINT runs, if a task fails to meet its definition of success, it will pull a random number from its stream and will use that to determine which failure consequence will be implemented.

If you choose to use the effect that assigns a different following task in the event of failure, make sure that you do not assign a rejoin task as the new following task. This will cause the model to run incorrectly. For more information, refer to multiple decision types.

Workload

Task Information

ID: Name:

Visual:

Auditory:

Cognitive:

Psychomotor:

< Previous Next >

OK Cancel Help

Time&Acc Effects Failure **Workload** Crew Assgn. Taxon

Figure 3-17. Task Information Dialog Workload Tab

This dialog is only accessible if you are working on a VACP mission. In the VACP method, the workload estimate is described by combining four channels: visual, auditory, cognitive, and psychomotor. You select the workload level for each channel by selecting the appropriate row in the pull down list in the respective work scale of Visual Workload Scale, Auditory Workload Scale, Cognitive Workload Scale, and Psychomotor Workload Scale.

The VACP workload theory that we have implemented in IMPRINT is discussed in detail in an Army Research Institute Technical Report (McCracken and Aldrich, 1984). We will discuss the basics of that report here, but if you want to learn more about this theory we recommend you consult that technical report.

Workload theory is based upon the idea that every task a human performs requires some work. Usually a task is composed of several different types of work, such as visual or cognitive. As an example, consider a task like steering a car. This task will have some visual work (watch where you are going), some cognitive work (decide if you are turning enough), and some psychomotor work (rotate the steering wheel). The workload theory in IMPRINT helps you assign values representing the amount of effort that must be expended in each channel in order to perform the task. To help you, IMPRINT displays a list of scale values and descriptors for each channel. These scales are taken directly from Bierbaum, Szabo, and Aldrich (1989).

If you are not sure precisely where to rate a task, we recommend that you rate the task on the high side, rather than too low. As you will see in the reports, IMPRINT will show you the workload peaks as the mission progresses. If, at that time, you see that one of your "questionable" workload ratings has led to a peak, you can investigate the task further to determine whether it is likely to lead to a problem in the "real world."

This theory also hypothesizes that if you are doing two tasks at once, the workload levels are additive within channels, across tasks. For example, if you are doing two tasks at once, one with a psychomotor load of 2.6 and one with a psychomotor load of 4.6, then IMPRINT would record a psychomotor score of $2.6 + 4.6 = 7.2$ for the time that the two tasks were being performed together. The value of each workload channel throughout the mission will be displayed for you in a graph in the reports. From this graph, you will be able to pick out the times during your mission that the workload "peaked." In addition, the graph will tell you what each operator was doing during these peaks so you can pinpoint the tasks that contributed to high workload for each operator.

Auditory Workload Scale

The auditory workload scale embedded in the VACP missions in IMPRINT is shown below:

Scale Value	Auditory Scale Descriptor
0.0	No Auditory Activity
1.0	Detect/Register Sound (detect occurrence of sound)
2.0	Orient to Sound (general orientation/attention)
4.2	Orient to Sound (selective orientation/attention)
4.3	Verify Auditory Feedback (detect occurrence of anticipated sound)
4.9	Interpret Semantic Content (speech)
6.6	Discriminate Sound Characteristics (detect auditory differences)
7.0	Interpret Sound Patterns (pulse rates, etc.)

Cognitive Workload Scale

The cognitive workload scale embedded in the VACP missions in IMPRINT is shown below:

Scale Value	Cognitive Scale Descriptor
0.0	No Cognitive Activity
1.0	Automatic (simple association)
1.2	Alternative Selection
3.7	Sign/Signal Recognition
4.6	Evaluation/Judgment (consider single aspect)
5.3	Encoding/Decoding, Recall
6.8	Evaluation/Judgment (consider several aspects)
7.0	Estimation, Calculation, Conversion

Psychomotor Workload Scale

The psychomotor workload scale embedded in the VACP missions in IMPRINT is shown below:

Scale Value	Psychomotor Scale Descriptor
0.0	No Psychomotor Activity
1.0	Speech
2.2	Discrete Actuation (button, toggle, trigger)
2.6	Continuous Adjustive (flight control, sensor control)
4.6	Manipulative
5.8	Discrete Adjustive (rotary, vertical thumbwheel, lever position)
6.5	Symbolic Production (writing)
7.0	Serial Discrete Manipulation (keyboard entries)

Visual Workload Scale

The visual workload scale embedded in the VACP missions in IMPRINT is shown below:

Scale Value	Visual Scale Descriptor
0.0	No Visual Activity
1.0	Visually Register/Detect (detect occurrence of image)
3.7	Visually Discriminate (detect visual differences)
4.0	Visually Inspect/Check (discrete inspection/static condition)
5.0	Visually Locate/Align (selective orientation)
5.4	Visually Track/Follow (maintain orientation)
5.9	Visually Read (symbol)
7.0	Visually Scan/Search/Monitor (continuous/serial inspection, multiple conditions)

Crew Assignments

The interface you see when you click on the Crew Assgn tab varies, depending on whether you are defining a VACP or an Advanced Mission.

VACP Mission Interface:

Task Information

ID: 1 Name: Receive Mission (Pilot)

Primary

MOS: OFF Crew Member: Pilot

Secondaries

MOS	Crew Member

Add
Delete

< Previous
Next >
OK
Cancel
Help

Time&Acc Effects Failure Workload **Crew Assgn.** Taxon

Figure 3-18. Crew Assignments

The operator assignments consist of four fields that are used to describe each crew member. The fields are the MOS, or Military Occupational Specialty, the crew member, and whether this is a Task Primary Operator assignment or a Task Secondary Operator assignment.

You select the MOS for this task by clicking on the down arrow with a line under it that is to the right of the MOS field. Clicking on the down arrow will provide you with a list of possible MOS assignments for this task. The list of MOS's would have been defined in the "Define Soldier" portion of IMPRINT.

The crew member is selected in the same manner as for selecting the MOS. You click on the down arrow to the right of the crew member field and a list of possible crew members will be displayed. Simply click on the desired crew member.

Advanced Mission Interface:

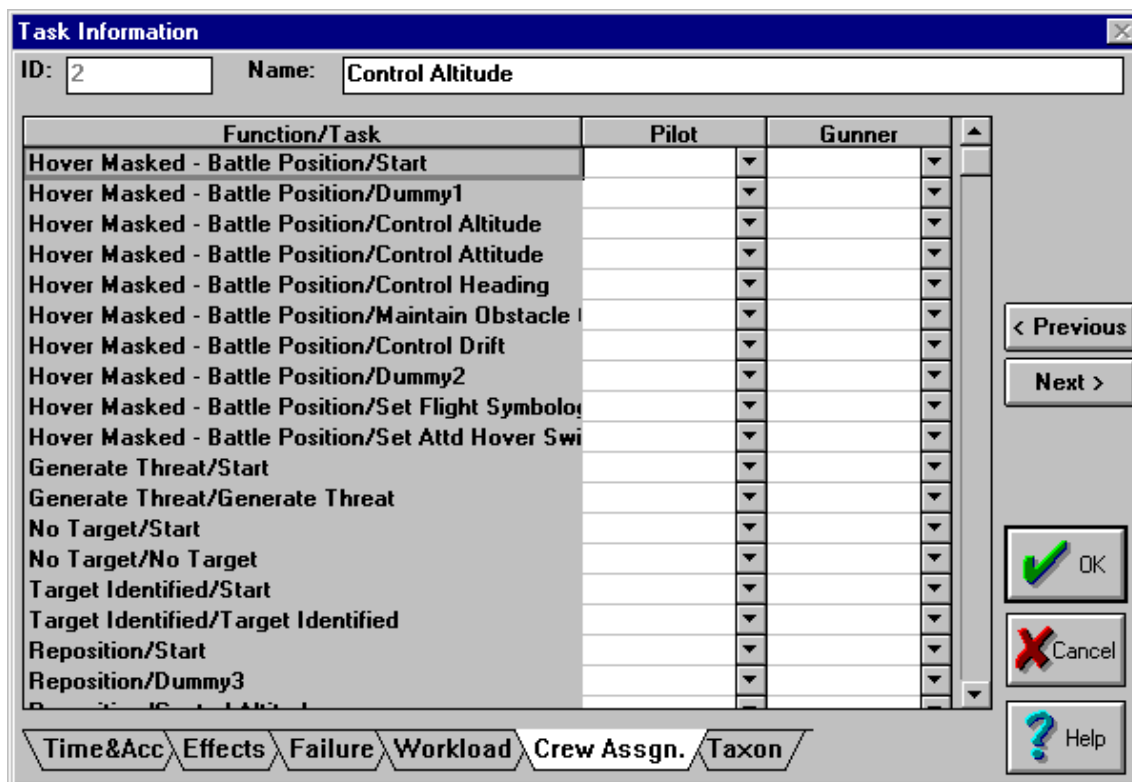


Figure 3-19. Advanced Mission Interface

In Advanced Missions, a crew member or automation device must be assigned to each task in the mission. Each task can be assigned to up to six primary operators. Each primary operator should be equally qualified and able to perform the task. As the task is scheduled to begin, IMPRINT will select the operator with the lowest workload level to perform the task.

You will also be able to assign crew members or devices contingency task responsibilities. Each task can have up to one contingency operator designated. Tasks can be reallocated during the simulation only to the designated contingency operator.

Operators that have primary responsibility cannot also be assigned contingency responsibility. Alter the values in the spreadsheet to define the primary and contingency task assignments.

A crew member or automation device must be assigned to each task in the mission. Each task can be assigned to up to six primary operators. Each primary operator should be equally qualified and able to perform the task. As the task is scheduled to begin, IMPRINT will select the operator with the lowest workload level to perform the task.

The Operator Assignment window displays a spreadsheet style interface with the task numbers and names down the left column, grouped by function, and the crew member and device names across the top. The spreadsheet cells are shown as boxes. Any

previous primary task assignments are indicated by “Primary” in the cells. Any operators that have been assigned contingency responsibility for a task are indicated by a “Contingency” in the cell.

To mark or unmark a task as being assigned to an operator, click on the cell in the row and column corresponding to the task and operator. IMPRINT will change display a drop box showing <blank>, Primary, and Contingency and allow the appropriate option to be selected.

Taxons

Task Information

ID: Name:

Perceptual:

◇ Visual Recognition / Discrimination

Cognitive:

◇ Numerical Analysis

◇ Information Processing / Problem Solving

Motor:

◇ Fine Motor - Discrete

◇ Fine Motor - Continuous

◇ Gross Motor - Light

◇ Gross Motor - Heavy

Communication:

◆ Oral

◇ Reading and Writing

Total Weight =

< Previous Next >

OK Cancel ? Help

Time&Acc Effects Failure Workload Crew Assgn. **Taxon**

Figure 3-20. Taxons

Taxons provide a method for you to describe the composition of your task. Taxons are used in IMPRINT to adjust estimated task times and accuracies when you apply Personnel Characteristics, Training Frequency or Stressor adjustments. If you do not want to enter taxons, but you have already entered workload assignments, AND you have a VACP mission open, then you can use the Map Workloads to Taxons capability under the Options menu.

The taxon assignments consist of four areas that describe the distribution of taxon assignments. These four taxon areas are perceptual, cognitive, motor and communication. You will give taxon weight values ranging from 0.0 to 1.0 to these taxons with the sum of the taxon weights being less than or equal to 1.0. At most, three

taxon weights can be used.

The perceptual taxon has one category and that is visual recognition / discrimination.

The cognitive taxon is broken down into two categories: numerical analysis and information processing / problem solving.

The motor taxon has four categories: fine motor - discrete, fine motor - continuous, gross motor - fine, and gross motor - heavy.

The communication taxon is broken down into two categories: oral, and reading and writing.

At the bottom of the screen is a button labeled Total Weight. You can click on this at any time to sum the weights of the taxons currently described.

More information on the taxons and how they are used in the modeling to change task level performance is available in a technical paper provided in Appendix A to this document.

Decision Types

When you draw paths between nodes on the network diagram, you will begin the process of identifying a decision type for each of the nodes in your network. The possible decision types are as follows:

- Single - The same node always follows this one.
- Multiple - More than one node will begin as soon as this one is completed. All following nodes will begin performing at the same time. You must specify a Rejoin Node for all multiple decisions.
- Probabilistic - More than one node will follow this one. Each following node has a probability of being selected. The sum of the probabilities must equal 100 percent.
- Repeating - This node will repeat itself before going on to its following node. There are three types of repeating nodes. You can select whether the node repeats a specific number of times, or whether it repeats until the clock reaches a specific time, or whether it repeats until the simulation ends. To specify a repeating decision type, you must draw a single path from the node back to itself, and one path to the node that will follow it once the repeating is complete (often, this will be the “END” node).
- Tactical - The tactical decision type is only available in Advanced Workload Missions. Any task with a tactical decision type causes one of the following tasks to execute at the completion of the lead task. The tactical expressions that you enter are used to determine which of the potential following tasks will be executed. The task whose tactical expression evaluates to the greatest value will follow the source task. If multiple following tasks have equal high tactical expression values, the first task listed will execute next.

Dummy Nodes

Sometimes it is convenient to use "dummy" nodes to clarify the flow of your mission. These dummy nodes can be either functions or tasks that will act as place holders in the function or task list and in the sequence. By not assigning times to these the node, they will not take any time in the mission simulation model and thus will not have an effect. It is for this reason that some of the functions and tasks in the library models have a performance time estimate of 0 minutes.

Rejoin Nodes

If you specify a multiple decision type, and you are defining a VACP mission, then you will need to enter where these multiple paths will rejoin. IMPRINT requires that the paths come back together at a single node. This requirement ensures that the simulation model will wait for all the parallel functions to finish before it proceeds to the next function. An example of a multiple decision is shown below.

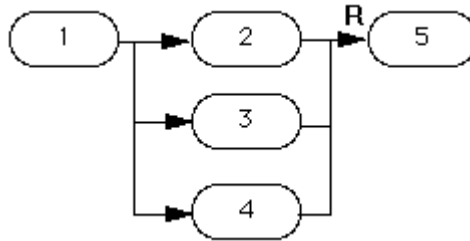


Figure 3-21. Example of a Multiple Decision

In this example, Task #1 has a multiple decision. Its following tasks are tasks #2, #3, and #4. All these paths rejoin at Task #5. Let's look at an example that is a bit more complex, as shown below.

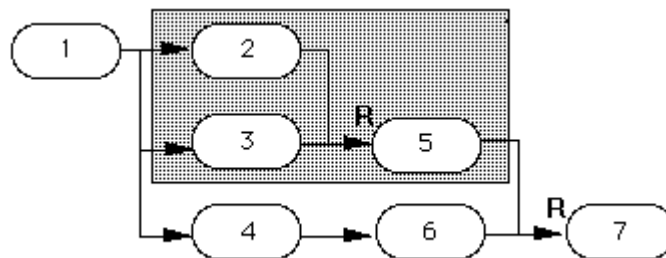


Figure 3-22. A Multiple Decision Following a Multiple Decision

In this example, Task #1 has a multiple decision. Its following tasks are the same as before, #2, #3, and #4. However, in this example tasks #2 and #3 rejoin at #5, and this path does not rejoin the path through #4 until #4 passes through #6 and rejoins at task #7. In order for IMPRINT to understand how to correctly manage this network, you will have to change it so that all parallel paths from a single task meet together at the same task.

You would have to insert a new "dummy" task as shown by task #8 in the figure below.

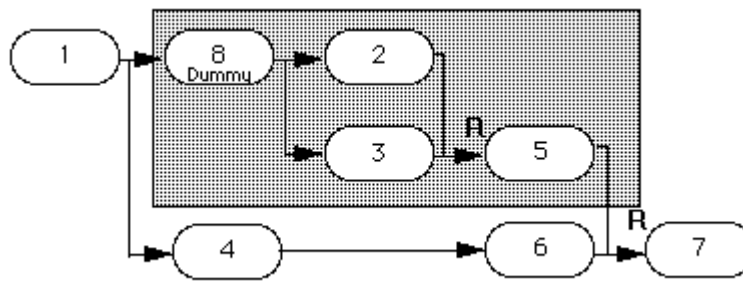


Figure 3-23. Use of Dummy Task

Now, task #1 still has a multiple decision. It goes to our new "dummy" task #8 and our original #4. Dummy tasks are tasks that perform no functional purpose for the model but do help you to solve problems like this one. Dummy tasks take no time to execute and have no effect on the performance of your model as long as you do not assign any tasks to the dummy task. In effect, they will be invisible to your mission. Now, the multiple paths from Task #1 rejoin at #7. Task #8 (our dummy) also has a multiple decision. It goes to #2 and #3. These paths rejoin at #5.

There are some subtle issues associated with making your network rejoin correctly. As the network executes, the rejoin node is instructed to wait until all the incoming paths are traversed before it releases. As each line coming into the rejoin node is traversed, it is counted. When the same number comes in as sent out by the multiple decision, the rejoin is released. For this reason, you should not identify a rejoin node as a "different task following" failure consequence. This is because, when that consequence is triggered, the network will "jump" to the rejoin task to attempt to start it and will not traverse the incoming path. Therefore, the counter will not be decremented properly. You can make this operate properly by inserting a dummy node immediately prior to the rejoin node, and use that node as your "different task following" task. Then, the incoming path to the rejoin will be traversed as needed.

The best way to determine whether the rejoin tasks are correctly identified in your model is to execute the model in the Animated mode. You can "single step" the animated presentation as the icons move through the network (use Cntrl t for single stepping). If you notice that the rejoin nodes are either not waiting for all the incoming paths to complete or if you receive the Micro Saint error "Task XX can never be released," then you have a rejoin problem. An additional way to determine whether your rejoins are correct is to study the Task Performance Report to make sure that the number of occurrences on every task is correct. If you have tasks that are occurring too many times in your mission, it is probably because the rejoin data are incorrect.

Crew

The interface you will see when you access this capability is different, depending on whether you are defining a VACP mission or an Advanced Mission.

VACP Crewmember Definition Interface:

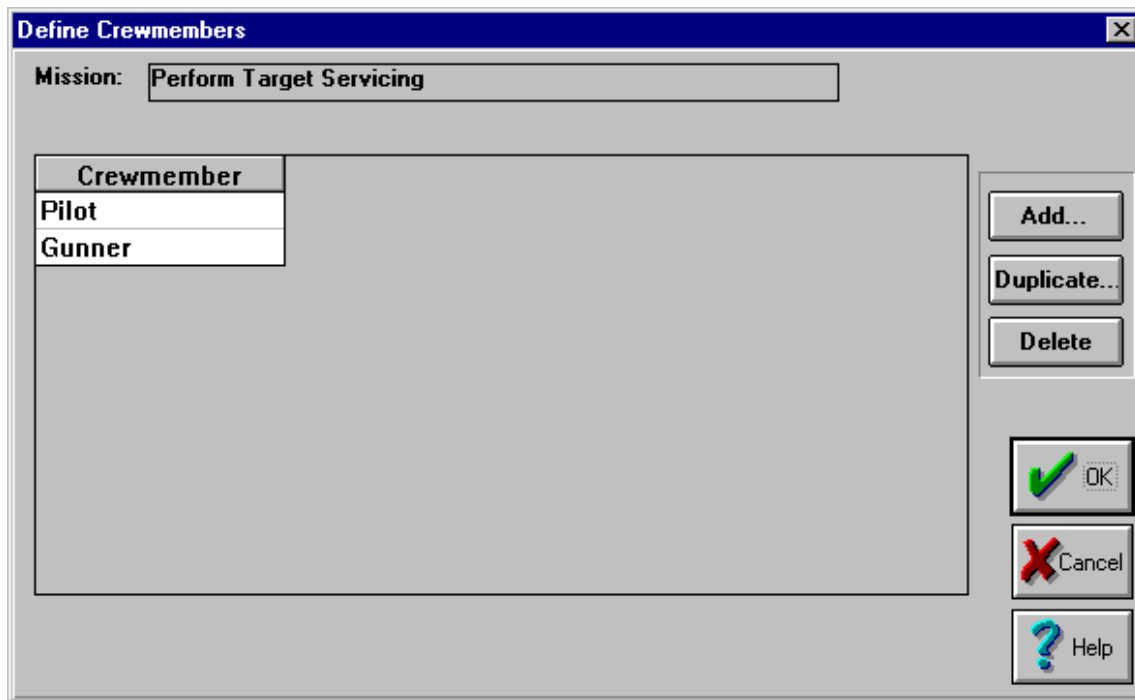


Figure 3-24. Define Crewmembers

Use this interface to add, duplicate and delete the names of the crewmembers to which you will assign tasks in this mission. Do not forget to also add operator MOS's in the Define Soldiers part of IMPRINT.

Advanced Workload Crewmember Definition Interface:

Define Crewmembers (Advanced Workload and Automation)

Mission: Moderator Effects

Crewmember	Automated	Experience	Aptitude	Fatigue *
Pilot	No	Inexperienced	CAT1	0.00
Gunner	No	Inexperienced	CAT1	0.00

Add...
Duplicate...
Delete

OK
Cancel
Help

* Fatigue represents the number of hours a crewmember has worked prior to the start of a mission

Figure 3-25. Define Crewmembers (Advanced Workload and Automation)

Use this interface to add, duplicate and delete crew members from your Advanced Workload Mission Model. Use the drop down boxes in the columns to indicate the characteristics of your crew members. If you identify a crew member as an automation device, by setting the "Automated" value to yes, then IMPRINT will not allow you to set workloads for tasks that are assigned to that crew member.

Each of the characteristics in this interface are attached to changes in task time and accuracy. Use the "Moderators" button to change the percent degradation for the characteristics.

Moderator Effects

Moderator Effects

Mission:

Operator	Experience	Effect	Aptitude	Effect	Fatigue
Pilot	Inexperienced	+15%	CAT1	-5%	0.00
Gunner	Inexperienced	+15%	CAT1	-5%	0.00

* Fatigue represents the number of hours a crewmember has worked prior to the start of a mission

OK Cancel Help

Figure 3-26. Moderator Effects

Use this interface to establish the level of impact that the moderator variables will have on task performance in an Advanced mission. You can specify the percent change that experience, aptitude and fatigue will have on task time and probability of success. Note that task time will be increased by this percentage, and the probability of success will be decreased by this percentage.

External Events

Scenario Event Menu

Mission Name:

Type	Appearance	Duration[s]	Function Triggered	Ta
Threat Appearance	0.00	0.00	Generate Threat	Gen

Add... Duplicate... Delete

OK Cancel Help

Description:

Figure 3-27. External Event Menu

External events are only applicable to Advanced Missions. External events allow you to identify a realistic set of events for your simulation, and to define their relationship to system and crew actions. Types of mission scenario events that IMPRINT allows are:

- threat events
- own-force events
- communication events
- changes in terrain or environmental conditions
- other

The External Events Window displays a list of any previously defined events in rows. The event type, appearance time, duration, function triggered, and task triggered are in columns for each event. A description note card area is also displayed. From this window, you will be able to add events, delete events, and copy events.

Each external event has several parameters associated with it. The parameters are:

- appearance time
- duration
- function triggered
- task triggered
- description

The appearance time identifies the time that the event occurs during the mission. To specify an appearance time, click in the appearance time field for the event. Use the numeric, backspace, arrow, and delete keys to enter the event appearance time.

The duration parameter identifies how long the event will last during the mission. To specify the event duration, click in the duration field for the event. Use the numeric, arrow, backspace, and delete keys to specify the event duration.

The function triggered parameter identifies how the event affects the mission by identifying the function that will begin when this event occurs. The task triggered parameter identifies how the event affects the mission by identifying the task that will begin when this event occurs. Before specifying a task to be triggered, you must identify the parent function of that task. To specify the function and task that are triggered, click in the appropriate field and select the name from the list.

Equipment

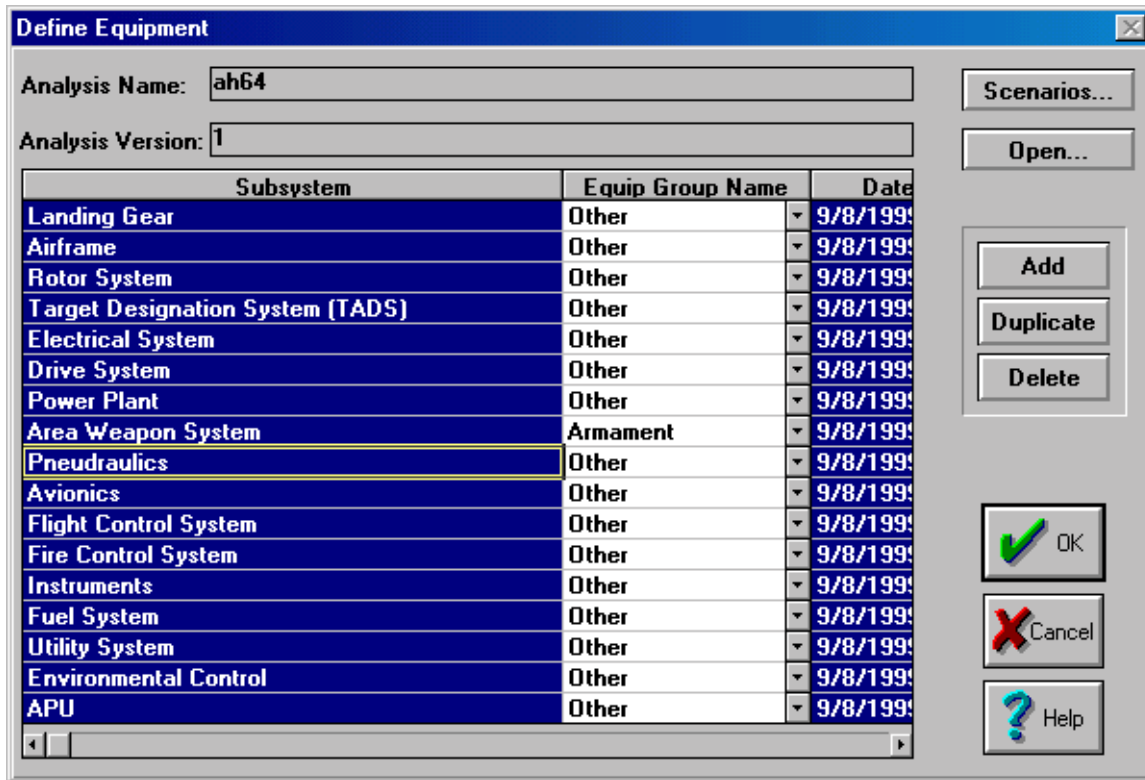


Figure 3-28. Define Equipment

The objective of the Define Equipment module is to help you estimate maintenance manhour requirements for your system. You can access this capability through the Evaluate Design button.

This module lets you enter parameters that control such items as the maintenance manpower pools, the spare availability, and the combat damage potential. These parameters, coupled with a mission schedule and the data describing the maintenance actions that your system may need are combined in a stochastic maintenance simulation. The primary purpose of the simulation is to predict the maintenance manhours required to attain an acceptable system availability.

To begin developing a description of the system equipment, choose the “Equipment...” option from the “Define” menu. When you make this menu selection, IMPRINT will display the Analysis Name along with a list of the equipment currently in the working database for the system you selected. This list also includes the date you last made changes to each piece of equipment.

To conduct an IMPRINT analysis of the maintenance manhour requirements to support a particular system, you will need to perform three basic activities.

(1) First, you will need to describe the maintenance requirements for the system by specifying the following information for each component system:

- how often the component needs to be maintained (i.e., rounds fired, time

- operated)
- the type of maintenance task that needs to be performed (remove & replace, repair, inspect, troubleshoot, etc.)
- the type and number of maintainers that are needed to perform the maintenance task
- how long it will take to perform each maintenance task
- whether the maintenance is preventive or corrective
- the maintenance organizational type at which the task needs to be performed (e.g., ORG, DS, GS)
- whether a contact team could perform the maintenance

This information will be contained in the IMPRINT “Define Equipment” dialog spreadsheet with a row for each maintenance task and a column for each of the maintenance parameters listed above. The data in the spreadsheet will be used as input to the IMPRINT maintenance simulation model.

If you are using IMPRINT to evaluate the maintenance requirements for a proposed new system in the acquisition cycle, you can enter the component maintenance parameters from scratch or from a system design, but it is more likely that you will begin by copying maintenance parameters from a similar library system and then modify existing components and/or add new components to reflect the system you are trying to evaluate.

If you are using IMPRINT for a different purpose, such as unit design, you may want to simply copy a library system and use it as is, using the same components and maintenance actions and modifying only the types of maintainers, maintenance levels, or other parameters for the existing components.

(2) The next activity that you will perform will be to build a simulation scenario that will define the conditions under which the system you are modeling will be used and the amount of usage the components in each system will incur. System usage and probabilities for combat damage will be determined by missions that you will define for the scenario. Each scenario can contain multiple missions.

(3) The final activity you will perform to prepare for the IMPRINT maintenance simulation run will be to define the unit configuration and support parameters for each scenario. These parameters include:

- Operational crew (per system) - This is an optional parameter, and the information defaults to an empty set of operational crew members.
- Maintenance shift manning (size, type) - This parameter defaults to the minimum possible shift manning, as well as one shift per day that is eight hours long. IMPRINT calculates the minimum shift manning by examining each maintenance task to find the minimum number of people in each specialty that will enable any given task to be performed.
- Spare parts (availability, wait times) - This is also an optional parameter and is specified at the subsystem level. This parameter defaults to 100% availability,

and a zero wait time.

This spreadsheet lists all the major subsystems for the system that you are analyzing. A major subsystem is typically something like an engine, landing gear, or main gun. The second column of the spreadsheet contains the equipment type. There are three possible equipment types. They are Armaments, Mobility, and Other.

The equipment type of each subsystem determines how the usage will be accrued to each component in the subsystem and the basis on which each component will require maintenance. Armaments subsystems will accrue usage and require maintenance based on rounds fired from that subsystem. Mobility subsystems will accrue usage and require maintenance based on the distance traveled by the system. Other subsystems will accrue usage and require maintenance based on the operational time.

From this screen, you can Open a subsystem and begin entering maintenance task data, or you can define the Scenarios under which this system will operate.

Scenario Button

Clicking on this button allows you to develop scenarios for the maintenance model.

Open Button

Clicking on this button opens a dialog that lists the components that are members of the subsystem that is highlighted.

Add Button

Clicking on the “Add” button allows you to type in the name of an additional subsystem. For the additional subsystem to impact the maintenance model, you must also provide component data.

Duplicate Button

Clicking on the “Duplicate” button will produce another subsystem with all its data exactly like the subsystem that is highlighted in the spreadsheet. You should give the replicated subsystem a name that is different than the original subsystem.

Delete Button

Clicking on the “Delete” button will delete the highlighted subsystem in the spreadsheet. It will also delete all information associated with that subsystem, such as all components and repair action data.

Components

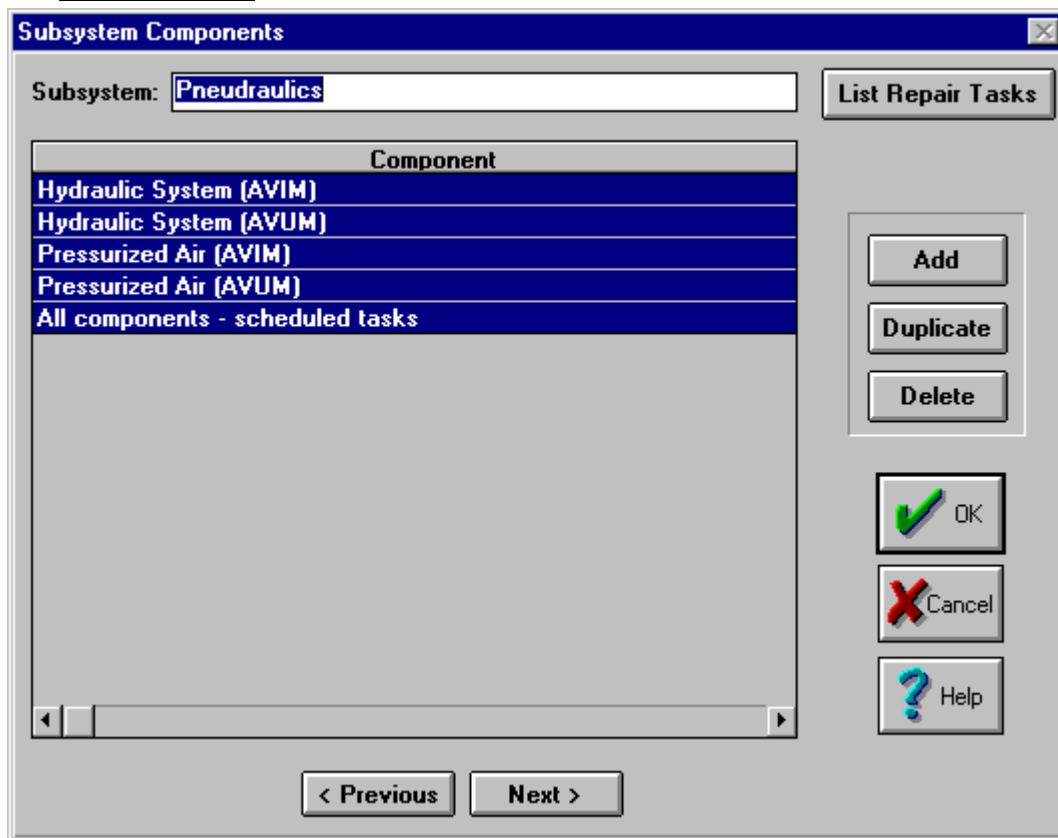


Figure 3-29. Subsystem Components

The Subsystem Components screen is accessed through the Evaluate Design Subsystem List by highlighting the subsystem for which you want to add or review data, and clicking on the “Open” button. Use this spreadsheet to enter a list of all the components in the selected subsystem, using the “Add,” “Duplicate,” and “Delete” buttons. After you have entered the components, press the “List Repair Tasks” button to enter the maintenance tasks and associated data for each component.

Use the “Previous” and “Next” buttons to progress through the list of subsystems.

Add Button

Clicking on the “Add” button allows you to type in the name of an additional component. For the additional component to impact the maintenance model, you must also provide component data.

Duplicate Button

Clicking on the “Duplicate” button will produce another component with all its data exactly like the component which is highlighted in the spreadsheet. You should give the replicated component a name that is different than the original component.

Delete Button

Clicking on the “Delete” button will delete the highlighted component in the spreadsheet. It will also delete all information associated with that component, such as repair action data.

List Repair Tasks Button

Click on this button to enter or edit maintenance data for all repair tasks associated with the components you have highlighted.

Repair Task Data

Component Repair Tasks

Subsystem: Set Display...

Component:

Action	Main	Orq	MOS	Grad	#	MOS 2	Grad	#	MOUBF	MTI
Adjust & Repair	Preve	DS	67R	20	3	67R	10	1	138.00	0.62
Inspect	Preve	DS	67R	30	1	67R	20	1	1321.00	0.55
Remove & Replace	Preve	DS	67R	10	1	67R	20	1	420.00	3.11

Buttons: Add, Duplicate, Delete, OK, Cancel, Help

Navigation: < Previous, Next >

Figure 3-30. Component Repair Tasks

Each component could require several possible maintenance actions. The parameters shown in columns to the right of the “Action” column are the maintenance parameters for each maintenance action. In other words, each row of the spreadsheet represents the maintenance parameters for one maintenance action.

The horizontal scroll bar at the bottom of the task spreadsheet lets you scroll to the right to view columns that will not fit into the window. Following is a description of each column.

Action - There are several possible maintenance actions.

Maint Type - There are two types of maintenance actions. Preventive maintenance is

scheduled at fixed intervals. However, it is only performed at times when the system is not on a combat mission. Corrective maintenance is required when a component fails as a result of usage or combat damage.

Level - This is an indication of the maintenance level that will perform the maintenance action. There are three possible maintenance levels

- Organizational (ORG)
- Direct Support (DS)
- General Support (GS)

You can edit the names for the maintenance levels under the “Options” menu, “Edit Org Levels” item.

MOS 1 - This is the first Military Occupational Specialty that is required to perform the maintenance. In most cases, only one MOS is needed.

MOS 1 Grade - This is the skill level for MOS 1. Skill levels include 10, 20, 30, 40, or 50.

- This column contains the number of maintainers of MOS 1 that are required to perform the maintenance.

MOS 2 - This column is used if a second MOS is required to perform the maintenance action.

MOS 2 Grade - This is the skill level for MOS 2. Skill levels include 10, 20, 30, 40, or 50.

- This column contains the number of maintainers of MOS 2 that are needed to perform the maintenance action.

MOUBF - Mean Operational Units Between Failure. This is the number of operational units between failure, or more accurately stated the number of operational units between the need for this maintenance action. Depending on the “Type” for this subsystem the units could be rounds fired, distance traveled, or the amount of time that the system has been operating. The actual time when the need for this action will occur in the simulation will be drawn from an exponential distribution with a mean of this value.

MTTR - Mean Time To Repair. This is a value representing the average time it takes to perform this maintenance action. This value and the standard deviation for the repair time (SD MTTR) are used to generate a simulated time for this maintenance action from a normal distribution with a mean of MTTR and a standard deviation of SD MTTR.

Abort % - This value represents the percentage of time that the need for this maintenance action will cause the entire system to abort the current mission and have the maintenance done immediately.

CT - Contact Team. This cell contains an indication (yes/no) of whether this maintenance action could be performed by a contact team. This does not necessarily mean that this maintenance action will be performed by a contact team. It also depends on whether a contact team has been defined, whether it has been enabled for the current run and whether there are enough contact team maintainers to perform this action.

As you can see, there are many more columns on the task spreadsheet than will fit into the workspace window. You can choose to display selected columns to customize the display for you needs. You select cells of the task spreadsheet by clicking on them. You can select a group of cells by pointing to a cell and holding down on the left mouse button while you drag the mouse to highlight the cells you want to select. To select an entire row or column, including cells not visible in the window, click on the row number or the column label.

Use the “Previous” and “Next” buttons to progress through the list of components.

Add Button

Clicking on the “Add” button allows you to select another repair action for this component.

Duplicate Button

Clicking on the “Duplicate” button will produce another repair action with all its data exactly like the repair action that is highlighted in the spreadsheet.

Delete Button

Clicking on the “Delete” button will delete the highlighted repair action in the spreadsheet.

Scenarios

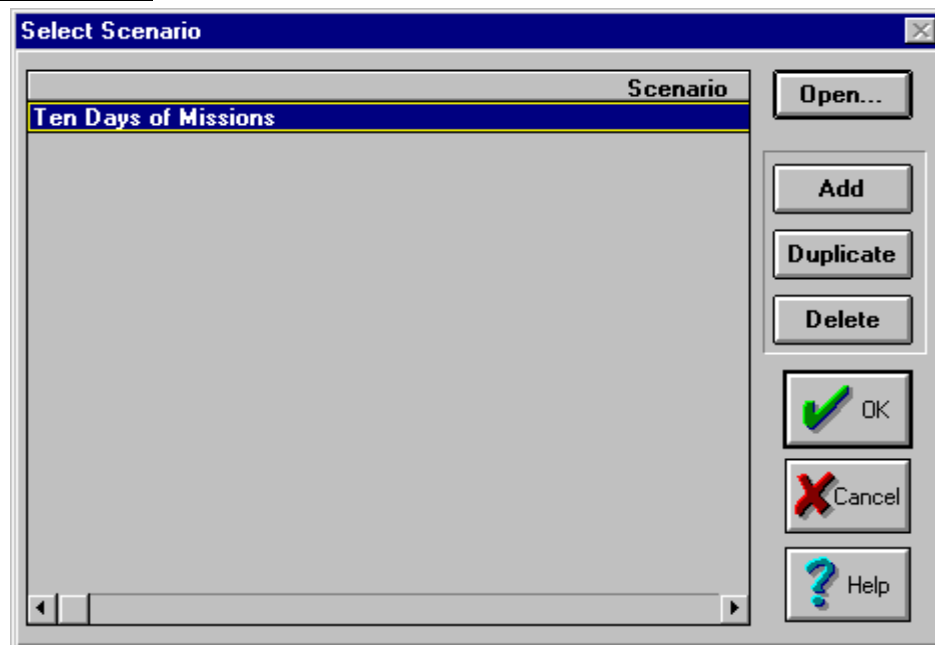


Figure 3-31. Select Scenario

This interface contains the list of scenarios available for your maintenance analysis. In order to view more information about a scenario, highlight it and press the “Open” button. This will let you edit and review the scenario parameters.

You can develop many scenario data sets for each system. For example, you might want to create one scenario for a thirty day run and another scenario that contains input parameters for a ten day run. When you have selected a scenario, this option also lets you add mission segment data for that scenario.

You can add, duplicate, and delete scenarios.

Open Scenario Button

Click on this button to open the scenario whose name is highlighted in the scenario spreadsheet. You can then review or edit data from that scenario.

Add Button

Clicking on the “Add” button allows you to type in the name of an additional scenario.

Duplicate Button

Click on the “Duplicate” button to add a new scenario that has a data set exactly like the scenario that is highlighted in the spreadsheet. You should give the replicated scenario a name that is different than the original scenario.

Delete Button

Click on the “Delete” button to delete the highlighted scenario in the spreadsheet. It will also delete all information associated with that scenario, such as segment data.

Scenario Parameters

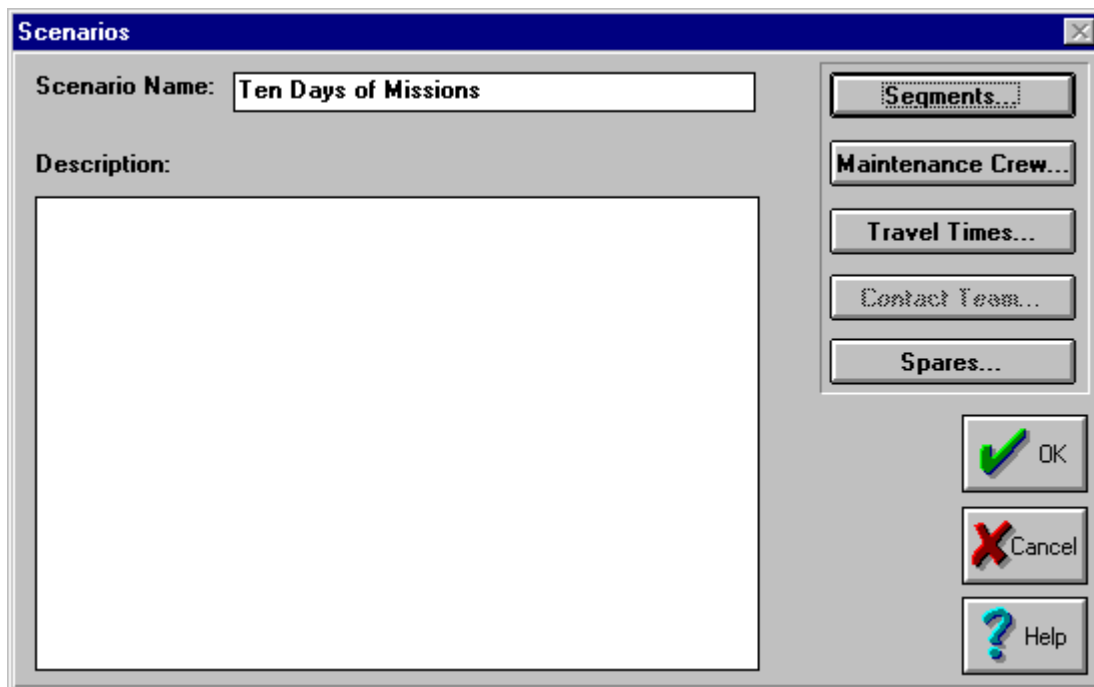


Figure 3-32. Scenarios

This screen contains information on the scenario you selected. You can enter a textual description of the scenario. Also, you can use the buttons on this dialog to access several different kinds of information attached to a maintenance scenario.

Segments Button

Use this button to decompose your scenario into individual mission segments.

Maintenance Crew Button

Click on this button to describe or review data on the maintenance concept. The maintenance concept consists of things such as the number of levels of maintenance, the numbers of shifts, the manning levels, and contact team utilization.

Travel Times Button

Click on this button to describe or review the delay times expected when moving the system from one level of maintenance to the next (e.g., from Direct Support to General Support).

Contact Team Button

Click on this button to describe or review expected travel times for the contact teams. If your maintenance concept does not utilize contact teams, this button will not be active.

Spares Button

Click on this button to describe or review the expected availability of spare parts needed for repairs and the delay times associated with obtaining spare parts. You can specify spare data at the subsystem level.

Segments

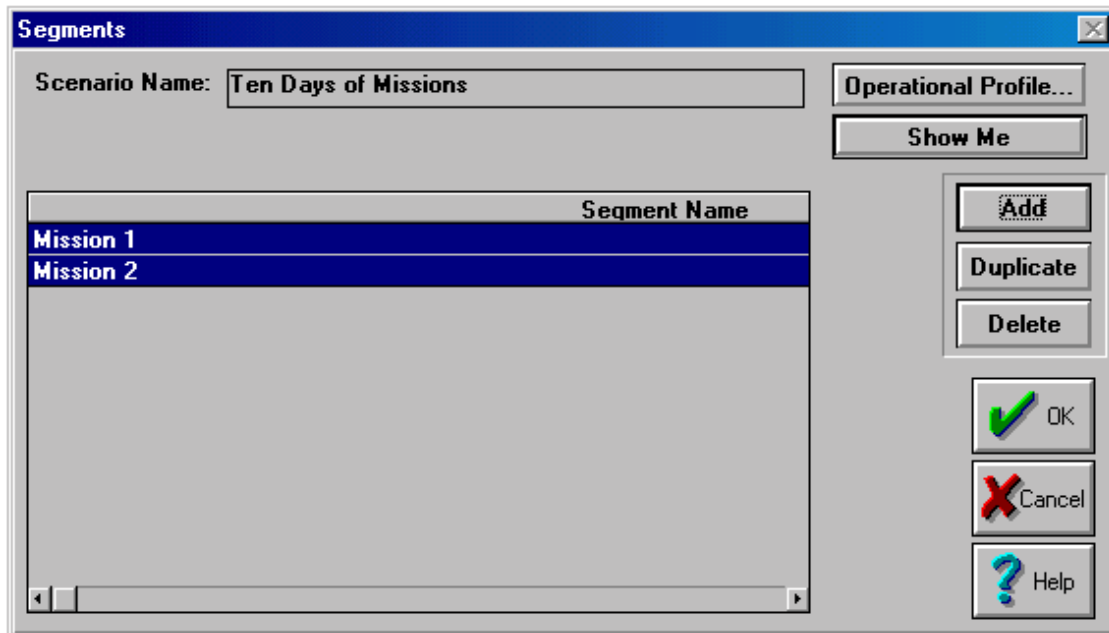


Figure 3-33. Segments

Each scenario is composed of a set of mission segments. These segments can be thought of as missions, in which a number of your systems are exercised. During a segment, the components accrue usage, which can lead to component failure. You can enter the parameters that are attached to a segment by pressing the “Operational Profile” button. (Do not confuse these missions with the operational missions described under the “Define System Mission” portion of IMPRINT. While they are similar concepts, none of the data you entered under “Define System Mission” will affect the results of your “Define Equipment” analysis.)

Add Button

Click on the “Add” button to type in the name of an additional segment. In order for the additional segment to impact the maintenance model, you must also provide segment data.

Duplicate Button

Click on the “Duplicate” button to produce another segment with all its data exactly like the segment that is highlighted in the spreadsheet. You should give the replicated segment a name that is different from the original segment.

Delete Button

Click on the “Delete” button to delete the highlighted segment in the spreadsheet. It will also delete all information associated with that segment, such as departure data.

Operational Profile Button

Click on this button to describe or review the operational profile of the segment you have highlighted. The operational profile contains segment data such as the start and stop times, times between departure, and number of systems needed.

Show Me Button

Click on this button to view the operational profile of the segment you have highlighted in a Gantt-like form. Most of the same data and editing functions that are available when you click the “Operational Profile” button are also available here.

Operational Profile

Scenario: Ten Days of Missions

Segment Name: Mission 1

Segment Description:

Segment Start Time: 00:00:00

Segment Start Day: 1

Cancellation Time: 00:30:00

Duration Time: 04:00:00

Segment Priority: 0.00

Minimum Number of Systems Needed: 0

Maximum Number of Systems Needed: 4

Number per Departure Group: 1

Time Between Departures: 10

☐ Repeating

Repeat Mean Time: 0

Standard Deviation: 0

Combat...

Consumables...

OK

Cancel

Help

< Previous Next >

Figure 3-34. Operational Profile

After you select a scenario and enter scenario parameters, IMPRINT presents you with a Operational Profile window on which you specify characteristics of the segments. You can define several segments for each scenario. For example, if you are modeling a large number of systems, you may want to define different missions for smaller subsets of your total number of systems. To develop a description of the Segments that make up your

mission, click on the Segments button from the Scenario dialog box. When you make this selection, IMPRINT will display a list of the segments currently in the scenario you selected.

The name of the Scenario you have selected and the Segment Name are displayed near the top of the dialog box. Below the Segment Name is a box in which you may type in a description of the currently selected segment. Below the Segment Description field are fields you may fill in to define parameters that will describe the operation of this segment. First is the Segment Start Time and Segment Start Day. Next is the Cancellation Time. These time values default to 00:00:00.00. This is followed by the Duration Time and Priority. You also must select the Minimum and Maximum Number of Systems Needed, the Number per Departure Group, and the Time Between Departures in minutes. If you want this segment to repeat, select the check box next to Repeating and enter the Repeat Mean Time and the Standard Deviation.

This dialog box also includes buttons along the right edge of the dialog box for further defining this segment. Select the “Combat...” button to enter the combat damage parameters for this segment. Select the “Consumables...” button to describe the number of miles traveled and rounds fired by the equipment during this segment.

At the bottom of the screen are buttons for going to the Previous and Next segments.

Combat Button

This button provides access to a dialog that lets you specify the probability and severity of combat damage likely to be encountered on this segment.

Consumables Button

This button provides access to a dialog that lets you specify the number of rounds fired by each weapon subsystem of your system for each hour of this segment. It also lets you access the distance traveled, and any load time required for the segment.

Combat

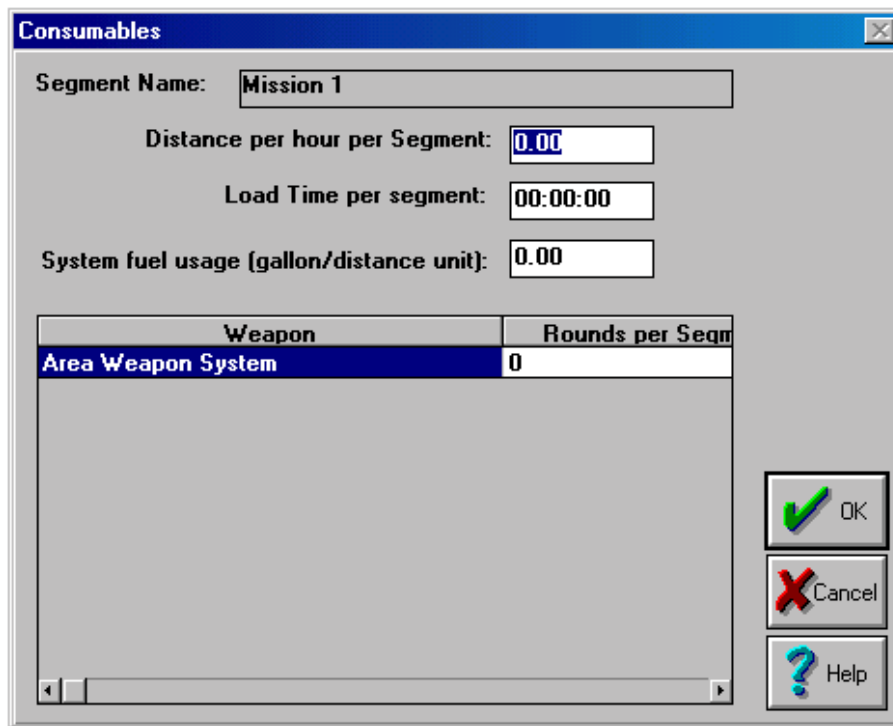
Figure 3-35. Combat

This dialog enables you to view and modify the combat damage parameters for this segment. Combat parameters include the following:

- the hourly probability that a system will sustain a combat hit
- given a combat hit, the probability that the system is a total loss
- if the system is killed, the number of hours before the system can be replaced
- given a combat hit, the probability that the system can be repaired
- if the system can be repaired, the amount of time needed to complete the repairs

The repair time will impact system availability, however it is not included in the maintenance manhour requirements reports. This is because IMPRINT doesn't know which component(s) needed repair due to combat damage, and therefore, doesn't know which MOS would be needed. Consequently, all time spent performing combat damage repair is reported in the Combat Damage report, and is not attributed to any particular MOS.

Consumables



Weapon	Rounds per Segment
Area Weapon System	0

Figure 3-36. Consumables

For each of the subsystems that were defined on the task spreadsheet there is an assigned “Type” of either Armament, Distance, or Other. For those subsystems that have a type of Armament, you need to specify the number of rounds of ammunition that will be fired from the weapon that contains that subsystem during this segment.

Additionally, on this dialog, you can enter the distance your system will travel during

each hour of the segment and any preparation, or load time, which is needed before the segment begins. The load time will not require manhours, but could affect system availability. You can also enter the amount of fuel used by the system in gallons per distance unit. This value is used to help IMPRINT calculate the Supply and Support requirements of each scenario.

The distance traveled and rounds fired are used to accrue usage to the components of systems as they perform the segments. Ultimately, this will cause components to fail, based on the Mean Operational Units Between Failure of each component.

Show Me

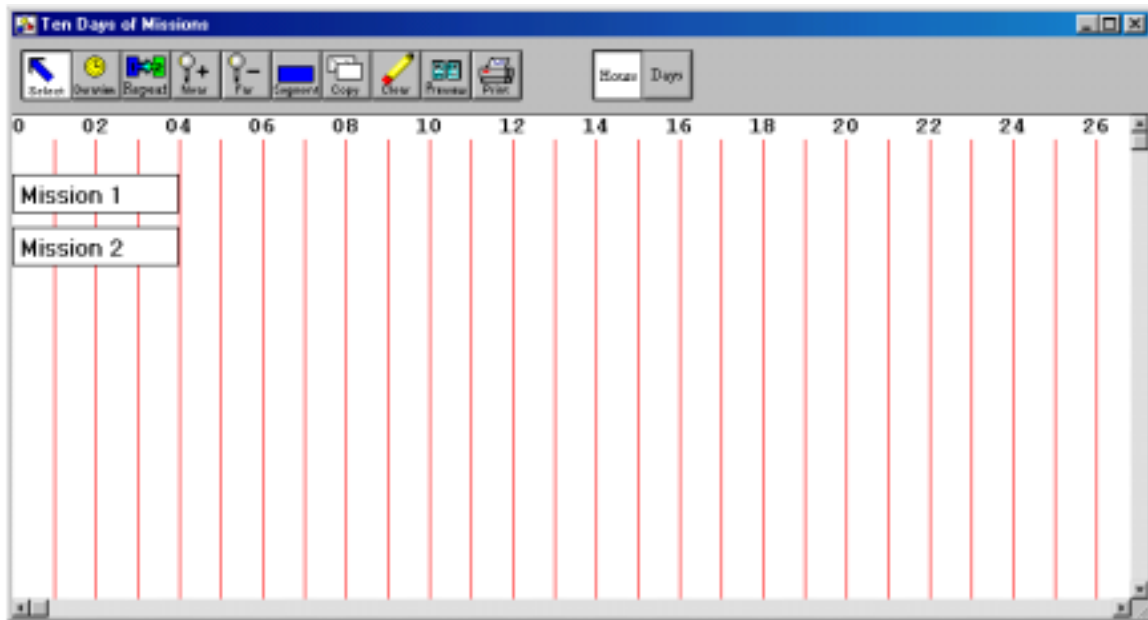


Figure 3-37. Operational Profile from a Different View

Another way to develop or edit the descriptions of the segments that make up your mission is to click on the “Show Me” button from the Segments dialog box. When you make this selection, IMPRINT presents you with a window containing a Gantt-like chart. The name of the scenario you have selected is displayed at the top of the dialog box. Below the scenario name is a tool bar that you may use to define parameters that will describe the operations of each segment in the scenario. Below the tool bar is a chart containing each Segment (represented as a bar) in the scenario.

The “Select” tool allows you to select a particular segment on the chart. Click once on the bar representing the segment you would like to edit. Then you can move the segment horizontally using your mouse to change the hour/day you would like the segment to begin. If you double-click on a segment, IMPRINT will present you with the Operational Profile window for that segment.

The “Duration” tool allows you to change the duration of a segment by adjusting the bar

length of a particular segment. To use the “Duration” tool, click in the segment bar that you want to change, and then drag the right edge of the bar to the length that you desire. If you want a segment to repeat, click once on the “Repeat” tool and then click once on the segment you would like to repeat. Text will appear on the bar of the segment you have chosen to inform you that the segment is repeating.

The “Near” and “Far” tools allow you to see the layout of the scenario from different viewpoints. The “Segment” tool allows you to add a new segment to the scenario and the “Copy” tool allows you to copy an existing segment.

The “Clean” tool allows you to delete individual segments one at a time from the scenario and the “Preview” button allows you to view the entire timeline of the scenario and all of its segments. The “Print” tool allows you to print this timeline

Finally, the “Hours” and “Days” buttons allow you to set whether the chart displays the timeline in either hours or days. Once you close this window, all of the changes you have made will be applied.

Maintenance Crew

MOS	Minimum	Shift Number	
		1	2
67R10	7	999	999
67R20	5	999	999
67R30	1	999	999
68B20	3	999	999
68D20	1	999	999
68F20	2	999	999
68G20	2	999	999

Figure 3-38. Maintenance Crew Limits per Shift

This option lets you define the shift manning for each specialty performing tasks at each maintenance level type (e.g., Unit, Direct Support, General Support). You can also identify shift manning for more than one shift. If you have edited the names of the different maintenance levels, your new labels will replace the ones shown above.

To set the shift manning, you use a spreadsheet that contains the number of people within each specialty for each maintenance shift that can work in parallel throughout your scenario. When you click one of the maintenance organizational type buttons, IMPRINT displays the spreadsheet for that level.

The number of hours in a shift and the number of shifts in a day are shown at the top of the dialog.

There is a check box available on the Execute Maintenance Model screen that lets you run the scenario in an unconstrained mode, regardless of the entries you make on this dialog. This means that IMPRINT will ignore the shift manning in this spreadsheet. In other words, any time a maintainer is needed to perform a maintenance action, that maintainer is assumed to be available. Essentially, this means that an unlimited number of maintenance tasks can be performed in parallel.

In the spreadsheet itself, you will see a column for each shift. As with all spreadsheets in IMPRINT, click in a cell of the spreadsheet to edit the contents of the cell. Select an entire row or column by clicking the row number or column name.

The column titled "Minimums" identifies the minimum number you can enter for your manning of each MOS at each organizational level. This minimum is calculated by examining your repair tasks to find the maximum number of people in a given MOS needed on a single repair task. This ensures that your crew will be able to perform every task that could occur.

In order to evaluate which MOS's are the most heavily utilized, we recommend you refer to the Headcount Histogram Report. This is discussed in detail under the Reports portion of this User's Guide.

Travel Times

Figure 3-39. Travel Times to Maintenance

This option lets you enter the average number of hours it takes to travel from where the system breaks down to the maintenance locations. These maintenance locations will be

labeled as shown above, unless you edit the level names, as discussed in the “Options” portion of this User’s Guide.

The travel time you enter, in hours, represents round trip travel. This time is added to the maintenance time for a system to more accurately reflect system availability. It does not affect maintenance manhours. It only affects the total time to repair the system.

Type in travel times to move the system to and between the different maintenance levels. These travel delay times will be used to predict how long it will take to transport the system (or the component) to the appropriate organizational level. Note that in the maintenance model, all first level (e.g., ORG level) maintenance is performed first, then second level (e.g., DS), then third level (e.g., GS). The travel time is a one-time assessment for each system each time it completes a mission segment and needs maintenance.

Contact Team

You can define parameters that determine how IMPRINT will model contact teams. The general rule in the IMPRINT maintenance model is that when enabled, the contact team will perform all of the maintenance actions as it has the MOS’s to perform as long as the following parameter is met:

The “Maximum number of systems routed to Contact Team at any one time” parameter indicates that if the number of systems waiting for contact team maintenance is larger than the number entered in this field, the system is sent to regular maintenance.

Spares

Wait Times for Spare Parts

Scenario Name:

Subsystem	% Available	Wait in Hours
Landing Gear	100.00	0.00
Airframe	100.00	0.00
Rotor System	100.00	0.00
Target Designation System (TADS)	100.00	0.00
Electrical System	100.00	0.00
Drive System	100.00	0.00
Power Plant	100.00	0.00
Area Weapon System	100.00	0.00
Pneudraulics	100.00	0.00
Avionics	100.00	0.00
Flight Control System	100.00	0.00
Fire Control System	100.00	0.00
Instruments	100.00	0.00
Fuel System	100.00	0.00
Utility System	100.00	0.00
Environmental Control	100.00	0.00
APU	100.00	0.00

OK Cancel Help

Figure 3-40. Wait Times for Spare Parts

Use this spreadsheet to specify (by subsystem) the percent of time a spare part will be available when needed for a repair action and, if not available, the delay time until it will be available.

This optional capability lets you enter the probability of spare parts being available when they are needed for maintenance. You can enter a different probability for each subsystem in the IMPRINT maintenance task spreadsheet. You can also enter the average wait time (in hours) for parts that are not available.

Spare availability only affects Remove and Replace tasks being performed at the first (e.g., Unit, Org, or AVUM) level of maintenance. If spares are not available when they are needed, it could reduce system availability.

Soldiers

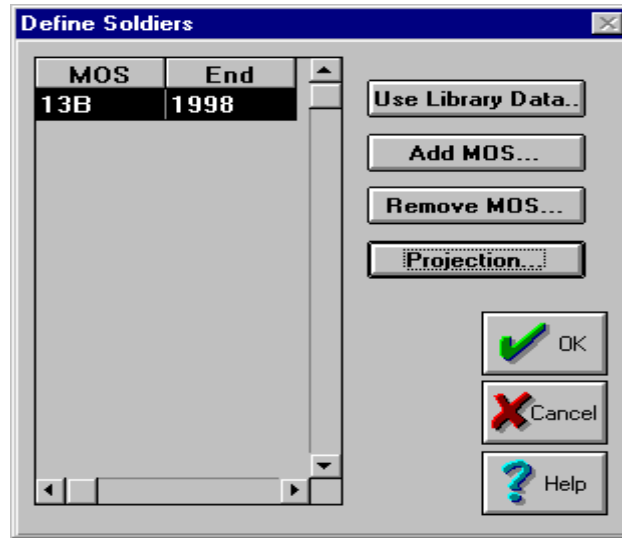


Figure 3-41. Define Soldiers

The objective of the Define Soldiers module is to help you estimate the types of people that will be available to operate and maintain the system that is the object of your manpower, personnel and training (MPT) analysis.

This module lets you select MOSs that are likely to be available (probably from a predecessor system) to operate and maintain the new system. It then permits you to “project” the MOSs into the future, when the new system will be fielded, to obtain estimates on their personnel characteristics.

A personnel flow model is used to make projections of what the selected Military Occupational Specialties (MOSs) are likely to look like in the future. The projections are based on historical trend data contained in the IMPRINT library. Within this module is also an option that allows you to change the historical trend data to reflect more recent personnel policies.

Since the system being supported by this analysis will not be fielded until sometime in the future, it is important that the personnel characteristics (and thus the performance) of the operators and maintainers be related to that time frame rather than now.

To begin developing estimates of future personnel characteristics, choose the “Soldiers...” option from the “Define” menu.

Add MOS Button and Remove MOS Button

MOSs can be added or deleted from the list of MOSs available for the new system by clicking on the “Add MOS” or “Remove MOS” buttons on the “Define Soldiers” dialog box. To add an MOS click on the “Add MOS” button. This will bring up an MOS Directory containing an ordered list of MOSs. The left most column gives the 3-digit code or designation for the MOS. As you cursor from MOS to MOS within the directory,

the title of the MOS is displayed below the directory. The last two columns give the Armed Services Vocational Aptitude Battery (ASVAB) composite and the composite cutoff score, which is used to select people for the MOS. Three "dummy" MOSs have been included in the directory (i.e., XXX, YYY, ZZZ). You can use these MOSs to represent new MOSs or civilians in your analysis.

To delete an MOS, highlight or select the MOS and then click on the "Remove MOS" button. It will be deleted from your analysis, but will still be available to other analyses through the library data.

Use Library Data Button

Click on this button to get a list of all library systems for which data (operator and maintainer MOSs) exist. By selecting a library system here all operator and maintainer MOSs for that system will be added to the MOS spreadsheet and the Replacement System column will display the name of the library system selected.

Projection Model

The primary purpose of the personnel projection model (flow model) is to capture and project trends for the types of people entering and leaving an MOS. This is important because different types of people (e.g., male vs. female or Mental Category I vs. Mental Category IV) have different capabilities and thus perform tasks at different levels of proficiency (assuming a fixed level of training). To estimate how well an MOS can perform tasks associated with a new system sometime in the future, we need to know generally what types of people will be in that MOS in future years.

The personnel projection model should not be used to estimate the precise numbers of people in each grade within an MOS. This is because the number of people, by grade, in an MOS is controlled, to a large extent, by personnel policies made at HQDA. These policies (such as promotion rates) are constantly reviewed and revised to keep the MOS at desired levels. Budgetary considerations are also key in determining strength levels within an MOS. The personnel projection model does not attempt to model either changing personnel policies or changes in manpower budgets.

You should normally run the projection model without changing the model parameters most of the time. If you elect to run the model without changing parameters, the flow model uses transition rates (i.e., a 0.5 promotion rate listed under E-4 indicates that 50% of the E-3s were promoted to E-4 that particular year) that are computed from historical data. It also uses Army endstrengths from the Program Objective Memorandum (POM) and projected accessions from an Army Research Institute (ARI) Propensity to Enlist study.

If you do want to edit these numbers, click on the "Change parameters" button.

In IMPRINT, the flow model is constrained by trying to reach the target number of people for each projection year. In other words, the model tries to fill the MOS with high-quality

people first and then, in order to meet the target number, fills it with lower and lower quality people. Often, this causes the MOS to have a lower average quality in the projected years.

Note: Running the flow model takes time. If you analyze numerous MOSs over numerous years, IMPRINT will take a few minutes to complete the analysis.

Projection Model Parameters

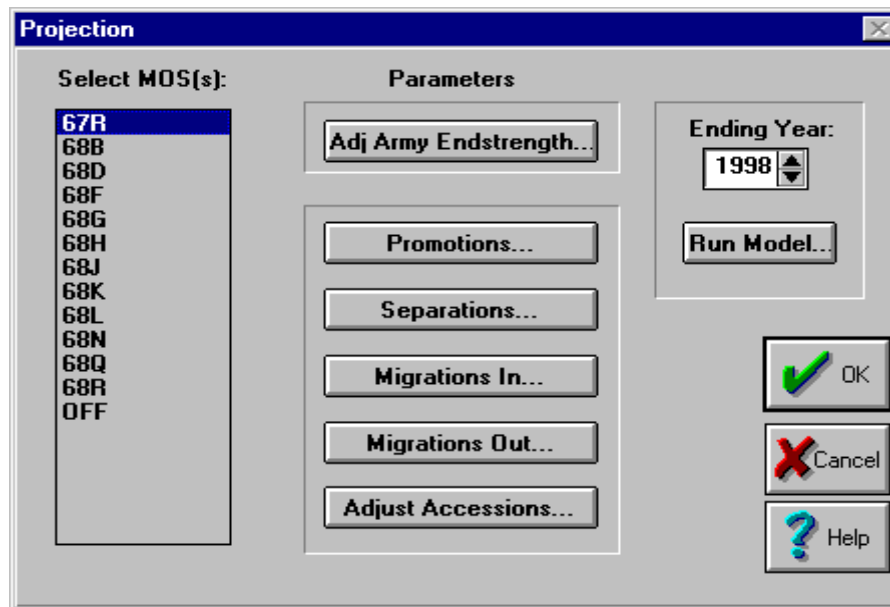


Figure 3-42. Projection

The personnel projection model uses historical data (normally Enlisted Master File (EMF) data from the past year) to estimate the rates with which different types of people move in and out of an MOS. There are advantages and disadvantages of using the past year's data to estimate trends and make projections based on them. The major advantage is that the data are current and reflect recent trends. The disadvantage is that abnormal behavior or radical restructuring of the MOS can be captured as a trend and projections may be unrealistic. The personnel flow model employs a modified Markov Chain algorithm to apply accession, continuation, promotion, and migration probabilities to determine projected inventories.

Please note that the personnel data in IMPRINT are as of a certain date (e.g., the end of FY97 or 31 September 1997). IMPRINT is updated periodically with personnel data from Personnel Command (PERSCOM) databases. The personnel transition rate data for IMPRINT Version 5.0 are from FY97 records. The personnel inventory data are as of 31 September 1997. The accuracy with which IMPRINT will describe MOSs is obviously dependent on when the data were last updated. Also, there are constant changes in the Enlisted Personnel Classification System whereby MOSs are deleted, created, and consolidated. IMPRINT personnel data may or may not reflect these changes, depending on when the data were last updated. The personnel projection model will only project

20 years into the future.

The model operates at the MOS, grade, year of service, and quality and demographic level of detail. It begins with the current inventory from the Army's EMF. It also uses the EMF to calculate historical transition rates (e.g., separations, promotions, migrations, etc.) for each subpopulation in an MOS. Subpopulations are defined by gender, high school graduate status, and test score category. The model also uses historical accession data from the EMF, Army end strength projections from the Army Program Objective Memorandum (POM), and estimated available accessions from an ARI propensity to enlist study. All these data are contained in IMPRINT libraries and provided automatically to users.

An example of an unrealistic projection could occur in the following manner. Say MOS XXX has grown rapidly during the past year in order to provide enough operators for a new vehicle being fielded. This growth could have occurred by obtaining E-4s and E-5s from other MOSs. (This would cause MOS XXX to have a large migration-in rate for those grades). If these same migration-in rates are used to project for future years, the E-4 and E-5 populations within the MOS will become unrealistically large - so large, in fact, that the MOS will try to maintain its overall strength by limiting the number of accessions that are allowed to come into the MOS. This, in turn, will cause the E1-3 grade to become unrealistically small. MOS XXX will then show a tremendous grade imbalance that would never have been allowed to occur.

When reviewing results from the personnel projection model, you should be aware that anomalies like the one described above can occur. You have two options when these anomalies occur. First, you can proceed with the analysis with the assumption that, although the grade structure within the MOS is misaligned, the changes in types of people within the MOS has been captured and is suitable for further analysis. The second, and more complicated option is to determine the cause of the anomaly by reviewing the transition rates (migrations, promotions, etc.) that were used in projecting the MOS. Having discovered an unusually low or high transition rate, you can then change it to reflect a more stable and realistic rate. Realistic rates can be obtained from other MOSs known to be relatively "stable" during the last year.

Force Structure

Define Force Structure

Replacement System: **M163 VULC**

Unit Parameters...

Phasing Schedule.

Parent Unit	Unit Type	Unit Size	#Units	#Systems	Total #
EAC and Others	AV(ROT)	Bn	1	55	55
82nd Airborne Div	AV(ROT)	Bn	1	18	18
101st Air Assault Div	AV(ROT)	Bn	3	18	54
1st Inf (Mech) Div	AV(ROT)	Bn	1	19	19
1st Cav Division	AV(ROT)	Bn	1	19	19
4th Inf (Mech) Div	AV(ROT)	Bn	1	18	18
3rd Inf (Mech) Div	AV(ROT)	Bn	2	18	36
5th Inf (Mech) Div	AV(ROT)	Bn	1	18	18
1st Armored Div	AV(ROT)	Bn	2	18	36
III Corps	Other	Other	1	2	2
III Corps	AV(ROT)	Bn	3	18	54
V Corps	AV(ROT)	Bn	4	18	72
XVIII Airborne Corp	Other	Other	1	1	1
XVIII Airborne Corp	AV(ROT)	Bn	3	18	54

Add...

Duplicate...

Delete

OK

Cancel

Help

Figure 3-43. Define Force Structure

Define Force Structure assists users in developing Army-wide estimates for manpower required to operate, maintain, and support a weapon system. Although Define Force Structure can be used in a “stand alone” mode (i.e., without running through Define Mission, Define Equipment, or Define Soldiers first), the most common case will be to use it last after conducting the other analyses.

Initially, you identify the types and quantities of units in the Army Force Structure for which manpower requirements will be computed. These will be the units in which the new system is scheduled to be fielded.

If you do not know what units to include in the Force Structure, you have the option of including all units that have the type of weapon system for which the analysis is being conducted. Define Force will automatically provide a list of all units that have the type of weapon for which the analysis is being conducted. You can then edit this list. The result is a list of active Army Tables of Operations and Equipment (TOE) units, by type and number, with the number of systems to be fielded, by year, for each type of unit.

In Define Mission you specify the crew members (and therefore crew size) for each weapon system. Define Force uses the specified crew size as a basis for estimating Army-wide requirement for operators for the new system. The number of required operators is a function of the types and numbers of units receiving the new system, the number of new systems being fielded, and the crew ratio. If you did not conduct a Define Mission analysis, you can enter the operator requirement from scratch.

Normally, you will have run a maintenance simulation in Define Equipment using a representative unit (or “pacing” unit) in which the new system will be fielded. Pacing units can be thought of as major building blocks within Divisions and Corps. In many cases pacing units will be battalions. For example, when modeling weapon systems in Infantry and Armor units, it is recommended that a battalion be modeled. In another case, if modeling a new system for a chemical unit, it is recommended that a company be modeled. The idea is to determine manpower requirements for the pacing unit, via modeling, and then multiply those manpower requirements by the number of those units in the Army, to get Army-wide manpower requirements.

The maintenance manpower requirements for the simulated unit (i.e., pacing unit) will be used in Define Force to compute manpower requirements for other units in which the new system will be fielded. The data from Define Equipment provide the basis for estimating Army-wide manpower requirements for all other types and sizes of units. Default values are provided for those units not modeled in Define Equipment.

This does not mean that you cannot change the Define Equipment numbers once they are brought into Define Force. You will have the option to edit them in Define Force. You can change the Define Equipment data by choosing to edit MMHs. The number of required maintainers is a function of the number and type of units, number of systems to be fielded, system reliability, maintenance ratio, operating tempo, and battle damage. If you did not conduct a Define Equipment analysis, you can enter these numbers from scratch.

Unit Parameters Button

Use this option to change the parameters of the units to which the new system will be assigned. You can change the operating tempo (OP Tempo), the maintenance manhours, and the crew ratio.

Phasing Schedule Button

Use this button to indicate to IMPRINT when each unit in the force structure will be getting the new system. You can also set the replacement ratio for which the new system will replace the current system.

Unit Parameters

Figure 3-44. Unit Parameters

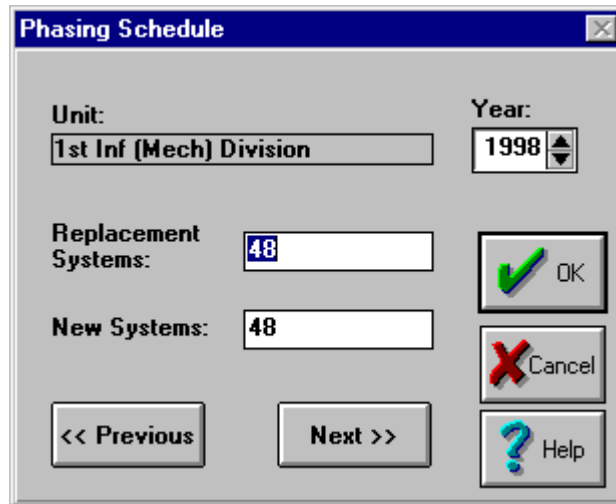
You use this screen to edit the operating tempo, maintenance manhours (MMH) per system for each maintenance organizational level, and the crew ratio for your new system in the identified unit. If you have executed a maintenance model, the values in the MMH/System text boxes will default to the values calculated by the model for any units that are appropriate.

The Annual OP Tempo is the usage per year that the new system is expected to accrue in the type and size unit listed. The OP Tempo is associated with a unit of measurement (e.g., flight hours, miles driven, etc.). The Annual MMHs/system (ORG, DS, & GS levels) are the total number of annual maintenance manhours (by maintenance level) required to maintain one new system in that unit. Finally, the Crew Ratio is the average number of crews available for each new system in the unit. In some cases where systems are required to operate continuously there may be multiple crews for each system.

You can use the "Previous" and "Next" buttons to move through each of your units on this dialog.

Note: If you edited the names of the maintenance organization levels, your new labels will be used on this dialog.

Phasing Schedule

A screenshot of the 'Phasing Schedule' dialog box. It has a title bar with a close button. The 'Unit:' field contains '1st Inf (Mech) Division'. The 'Year:' field is a spin control set to '1998'. The 'Replacement Systems:' field contains '48'. The 'New Systems:' field contains '48'. On the right, there are three buttons: 'OK' with a green checkmark, 'Cancel' with a red X, and 'Help' with a blue question mark. At the bottom, there are two buttons: '<< Previous' and 'Next >>'.

Unit:	1st Inf (Mech) Division	Year:	1998
Replacement Systems:	48	OK	
New Systems:	48	Cancel	
<< Previous		Next >>	
		Help	

Figure 3-45. Phasing Schedule

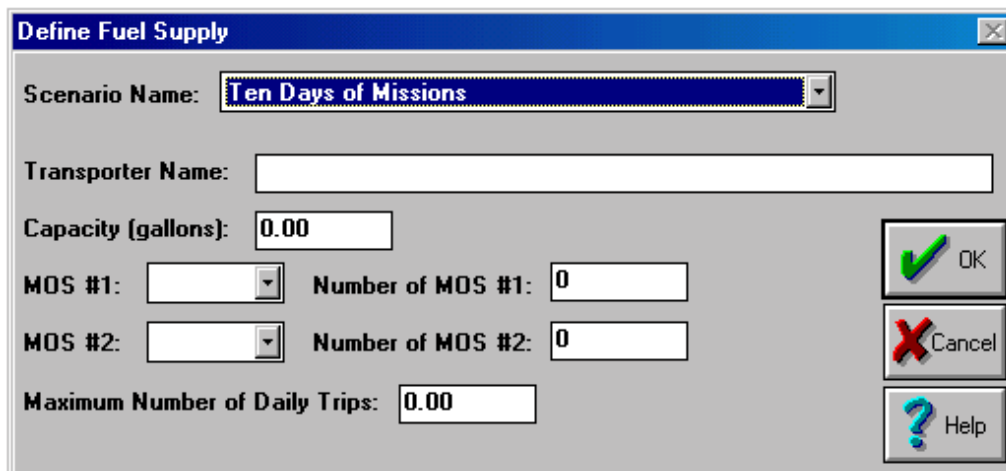
You can use this screen to tell IMPRINT how you want the new systems phased into your unit. The phasing will default to a 1:1 ratio of Replacements Systems to New Systems.

The “# Replacement Systems” is the number of old systems that will be replaced in that unit. The “# New Systems” is the number of new systems that will be fielded in that unit. You can use the “Year” spin control to select the year in which the old replacement systems will be exchanged for new systems.

Supply

You can enter information regarding how the necessary fuel and ammunition will be supplied to your systems in each scenario under this IMPRINT option. This information, along with the data entered under Define Equipment, allows IMPRINT to calculate the number of transporters and the associated manpower that will be required to support each scenario.

Fuel

A screenshot of the 'Define Fuel Supply' dialog box. It has a title bar with a close button. The 'Scenario Name:' field is a dropdown menu showing 'Ten Days of Missions'. The 'Transporter Name:' field is empty. The 'Capacity (gallons):' field contains '0.00'. There are two rows for MOS: 'MOS #1:' with a dropdown and 'Number of MOS #1:' with a text field containing '0'; and 'MOS #2:' with a dropdown and 'Number of MOS #2:' with a text field containing '0'. The 'Maximum Number of Daily Trips:' field contains '0.00'. On the right, there are three buttons: 'OK' with a green checkmark, 'Cancel' with a red X, and 'Help' with a blue question mark.

Scenario Name:	Ten Days of Missions		
Transporter Name:			
Capacity (gallons):	0.00		
MOS #1:		Number of MOS #1:	0
MOS #2:		Number of MOS #2:	0
Maximum Number of Daily Trips:	0.00		

Figure 3-46. Define Fuel Supply

From the main menu item “Define” choose “Supply” and then “Fuel.” You will then be presented with the dialog shown above. First, you need to select which scenario you want to set the fuel supply for. Then, you need to enter the Transporter Name, the capacity of that transporter, the manpower required for the transporter, and the maximum number of trips the transporter makes in a single day.

Ammunition

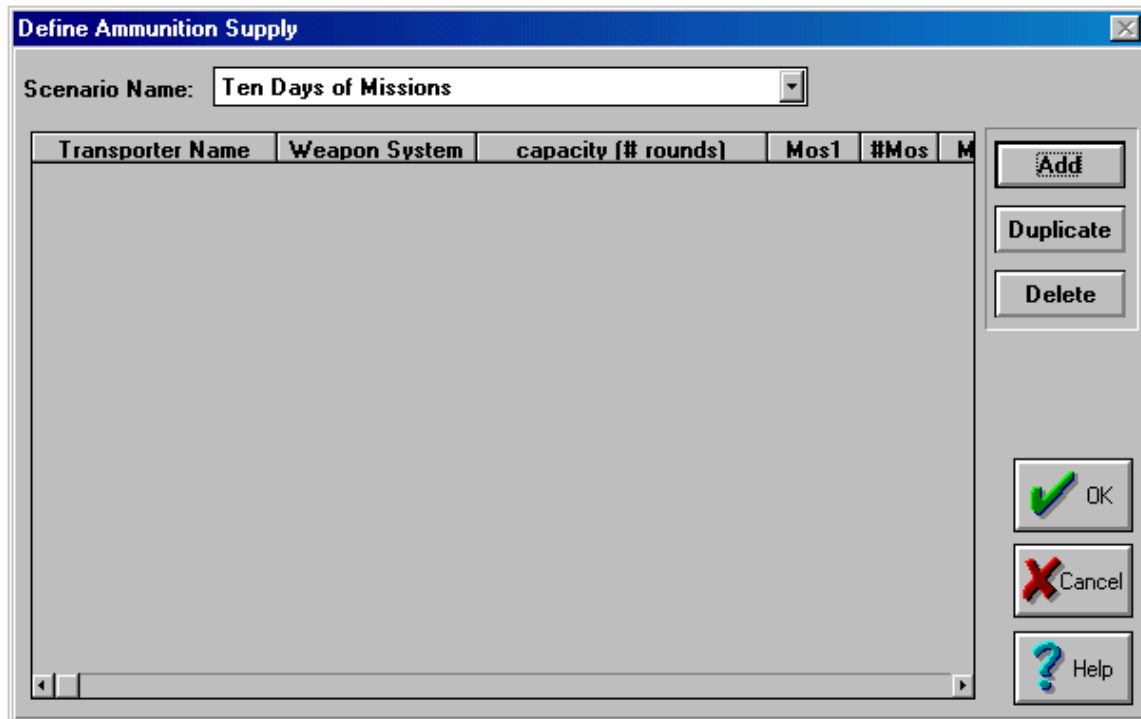


Figure 3-47. Define Ammunition Supply

From the main menu item “Define” choose “Supply” and then “Ammunition.” You will then be presented with the dialog shown above. First, you need to select which scenario you want to set the ammunition supply for. Then, for each Weapon System, you need to enter the Transporter Name, the capacity of the transporter, the manpower required for the transporter, and the maximum number of trips the transporter makes in a single day.

Options Menu

Edit Org Levels

This option allows you to change the names of the maintenance organizational levels. You are limited to 10 characters. Once you edit these levels, the new names will show up on all interfaces and reports that refer to the maintenance organizational levels.

Overall Workload

Figure 3-48. Overall Workload

This option allows you to define an overall workload measure for VACP Missions. In essence, it is used to combine the four workload channels into a single combined channel. For example, if you think that cognitive workload is twice as important as visual, psychomotor, and auditory in its contribution toward the total work an operator might feel, then you might be interested in tracking the value of an "Overall" channel that weights each of the existing channels to represent your hypothesis. Your "Overall" channel could be computed as follows:

$$O = 4 * C + V + P + A$$

where;

O = Overall
 C = Cognitive
 V = Visual
 P = Psychomotor
 A = Auditory

In the reports, where the results of the workload in each channel are reported, the report will include values for "O" as the mission timeline progresses.

Clear Last Entry Button

This button, when clicked clears the last channel, operator, or number entered into the overall workload expression.

Clear Overall Workload Button

This button, when clicked, clears the entire overall workload expression in the overall workload text box.

High Workload Definitions

Figure 3-49. High Workload

High Workload Definitions are used to identify high workload levels for crew members. This is only applicable to VACP missions. When your IMPRINT system mission model runs, the current workload levels of each operator are added across all tasks that the operator is performing. The sum is compared to each of the high workload definitions. If the current workload meets or exceeds any of the definitions, that segment of the mission is marked as "high workload." Later, in the reports, you will be able to recall and study each point of "high workload." The report will also list the workload threshold that was violated.

You define high workload in terms of the individual workload channels (V = Visual, A = Auditory, C = Cognitive, P = Psychomotor), the overall channel (O), and the number of ongoing tasks for each operator (N). You can combine any or all of these terms in your

definitions. For instance, if you want to define high workload as any time any operator is trying to perform more than two tasks at once, then your definition would be "N>2." If you want to define high workload as any time Auditory is more than 4 at the same time that Cognitive is more than 4, then your definition would be "A>4 & C>4." You can enter up to four separate high workload definitions.

Add to Threshold Button

Click on this button to move high workload channel definitions into the threshold box. Once in the threshold box, the model will then record and report high workload based on the thresholds.

Map Workload to Taxons

The purpose of this option is to enable you to convert any VACP Workload assignments you have made for your tasks into Taxon assignments. This automatic option could save you a lot of time.

IMPRINT uses the following relationships to make the conversions.

If you have entered workload values of:

- Visual 1.0, Visual 3.7, Visual 4.0 or Visual 5.0, then IMPRINT will assign this task to the Visual Taxon.
- Cognitive 7.0, then IMPRINT will assign this task to the Numerical Taxon.
- Cognitive 1.0, Cognitive 1.2, Cognitive 3.7, Cognitive 4.0, Cognitive 5.3 or Cognitive 6.8, then IMPRINT will assign this task to the Information Processing Taxon.
- Psychomotor 2.2, Psychomotor 4.6, Psychomotor 5.8 or Psychomotor 7.0, then IMPRINT will assign this task to the Fine Motor Discrete Taxon.
- Psychomotor 2.6, then IMPRINT will assign this task to the Fine Motor Continuous Taxon.
- Auditory 4.9, Auditory 6.6, Auditory 7.0, or Psychomotor 1.0, then IMPRINT will assign this task to the Oral Communications Taxon.
- Visual 5.9, or Psychomotor 6.5, then IMPRINT will assign this task to the Read & Write Communications Taxon.

Notice that none of the VACP workload scores map into either the Gross Motor Light or Gross Motor Heavy Taxons.

We recommend that you use either the Review Task spreadsheet or the Task Taxon Assignment capability to evaluate the assignments that IMPRINT made.

PTS

You can set Personnel Characteristics, Training Frequency, and Stressor (PTS) values under this IMPRINT option. We recommend that you make adjustments in these areas in the same order of the tabs (i.e., P, then T, then S). This is because the Personnel Characteristics describe the attributes with which the soldiers who will man your system

will arrive. Then, you can train those soldiers to perform the tasks. Finally, when the soldiers actually perform the tasks, they will be subjected to environmental stressors.

In all of these effects, IMPRINT calculates the impact of the PTS variable change on the estimated task performance (time and accuracy). The amount of impact is reported to you. If you then execute the maintenance or operations model with the Adjustments option checked, these “moderated” performance times and accuracies will be used by the model. If you do not check the Adjustments option, then the model will execute with the original task time and accuracy estimates that you entered under the Define Mission interfaces.

Specific technical information regarding the precise algorithms that are used in this module, as well as the source of these algorithms can be found in Adkins and Dahl (1993) and in a paper included in Appendix A of this User’s Guide.

Personnel Characteristics

Figure 3-50. Assign Personnel Characteristics

From the main menu item “Options” choose “PTS.” You can then choose whether you want to apply the impacts of personnel characteristics by individual task, or whether you want to apply them by MOS. Regardless of which you choose, you will be presented with

the tabbed dialog shown above, but if you select to apply them by MOS the individual task list will not be accessible.

This option allows you to change the Armed Services Vocational Aptitude Battery (ASVAB) composite, the cutoff score, and the Mental Category level for the Military Occupational Specialty (MOS) performing the tasks. The current ASVAB composite and cutoff score used to select people for the MOS are shown initially in the dialog box. You can edit these values.

If you change the ASVAB composite and cutoff score, you are, in effect, changing the MOS. This is because you have redefined the personnel characteristics of the MOS. Note that if you go back to the Task information (either under Define Equipment or Define System Mission) and change the MOS assignment, IMPRINT will connect the baseline performance time and accuracy estimates you make to that MOS. The only way to “simulate” a new MOS assignment and the impact that will have on task performance is through reassigning the ASVAB composite and cutoff on this screen.

There are two separate, but related options for setting minimum (i.e., cutoff) scores for personnel characteristics. Both options involve measures obtained from the Armed Services Vocational Aptitude Battery (ASVAB). The ASVAB is a battery of tests administered to enlistees prior to entering the military services. It is important to note that changes in the Test Score Category Cutoff will cause IMPRINT to automatically update the ASVAB Composite Cutoff to reflect the new Test Score Category that you have selected. IMPRINT will also automatically update the Test Score Category Cutoff to reflect changes to the ASVAB Composite Cutoff. The two options are as follows:

1. Change Test Score Category Cutoff - This option allows you to set a minimum "mental category" for a Military Occupational Specialty (MOS) and then see how performance would be affected. Mental category (now called "Test Score Category") refers to the general aptitude, and is from the score obtained on the Armed Forces Qualification Test (AFQT), which is derived from the ASVAB.

The different Test Score Categories are:

Test Score Category	AFQT Score
I	93-99
II	65-92
IIIA	50-64
IIIB	31-49
IV	10-30

When you pick a Test Score Category cutoff, the MOS will include the chosen Test Score Category and all others above it (e.g., Choosing "IIIA" will result in the MOS having mental categories I, II, and IIIA). At the same time, IMPRINT will automatically estimate the ASVAB cutoff that is associated with the Test Score Category cutoff you select. Again, once you have selected and applied a particular Test Score Category you

can see a report summarizing the impact that your choice has had on task Accuracy, Time, and the Probability of achieving the minimum acceptable accuracy by clicking on the “review” button.

2. Change ASVAB Composite Cutoff - This option allows you to set a minimum ASVAB Composite score for the MOS and then see how performance would be affected. The ASVAB itself consists of 10 subtests from which "composites" are constructed by combining two or more of the subtests. Each MOS uses one or two of the composites to control who can enter the MOS. This is done by setting composite cutoff scores, which must be attained in order to enter the MOS. Each MOS is assigned a composite(s) which is best for measuring the skills and aptitudes required to perform jobs well in the MOS.

When choosing an ASVAB composite cutoff score, you should realize that a higher cutoff score will generally result in better performance within the MOS; however, there will be fewer people available that can attain the higher cutoff score. Once you "Apply" your choices, you will see a report summarizing the impact that your Composite score changes have had on task Accuracy, Time, and the Probability of achieving the minimum acceptable accuracy.

ASVAB Composite

This option allows you to change the Armed Services Vocational Aptitude Battery (ASVAB) composite for the Military Occupational Specialty (MOS) performing the tasks. The ASVAB itself consists of 10 subtests from which "composites" are constructed by combining two or more of the subtests. The current ASVAB composite used to select people for the MOS is shown initially in the dialog box. You can select another ASVAB composite to be used from a drop down menu that will appear when you click on the drop down control.

ASVAB Cutoff

This option allows you to change the Armed Services Vocational Aptitude Battery (ASVAB) composite cutoff score for the Military Occupational Specialty (MOS) performing the tasks. The current ASVAB cutoff score used to select people for the MOS is shown initially in the dialog box. You can edit this value by selecting a different cutoff value from the drop down menu that will appears when you click on the drop down control. Higher cutoff scores will normally result in better performance but will cause less people to be available for the MOS.

Apply Button

When clicked, this button applies the chosen ASVAB composite cutoff. You should realize that a higher cutoff score will generally result in better performance within the MOS; however, there will be fewer people available that can attain the higher cutoff score. Once you "Apply" your choices, you will see a report summarizing the new performance estimates and a “Delta” column that includes the impact that your changes have had on the MOST RECENT values for task accuracy, time, and the probability of achieving the minimum acceptable accuracy. So each time you press “Apply,” the

performance estimates will be a combined calculation based on all PTS settings so far, and the Delta values will show the amount of change from the immediately preceding “Apply” button click. If you want to “Unapply” your choices, you must go back to the combo boxes where the settings were changed, adjust them so that they are in the N/A or 0 levels, and “Apply” these values again.

Review Button

Click on this button to review any effects on task performance of applying personnel characteristics changes to your MOSs.

Training Frequencies

Assign Training Frequency

MOS and Job:
67R

Mission:
N/A

Function:
N/A

Tasks:
Adjust & Repair Landing Gear Assembly (AV)
Adjust & Repair Main Trans. Acc. Gearbox
Adjust & Repair Hydraulic System (AVIM)
Adjust & Repair T. Rotor Direct. Controls (A
Adjust & Repair Air Data Sensor System (A
Adjust & Repair Landing Gear Assembly (AV
Adjust & Repair Empennage (AVUM)
Adjust & Repair Main Rotor Blade (AVUM)
Adjust & Repair Main Trans. Acc. Gearbox
Adjust & Repair Engine (AVUM)
Adjust & Repair Hydraulic System (AVUM)
Adjust & Repair T. Rotor Direct. Controls (A
Adjust & Repair Fuel System, Other

Training Frequency:
Once a month

Review...
Apply

OK
Cancel
Help

Personnel Characteristics Training Frequency Stressors

Figure 3-51. Assign Training Frequency

From the main menu item “Options” choose “PTS.” You can then choose whether you want to apply the impacts of training frequencies by individual task, or whether you want to apply them by MOS. Regardless of which you choose, you will be presented with the tabbed dialog shown above. Training frequencies are on the second tab.

This option allows you to review and edit training frequencies for each task. One of five training levels can be assigned to a task. You should choose the training level which best describes how often operators or maintainers will perform the task. Performance of the task could be part of a training exercise or actual job performance. In general, the more frequently an individual practices or performs a task, the more accurately they will

perform it. Also, an increase in training frequency normally will decrease the time required to perform the task.

If you are trying to improve task performance to meet accuracy or time standards, increasing training frequency is one possible alternative. An increase in training frequency, however, will often require additional resources (e.g., an increase in the frequency with which soldiers zero the sights of their weapons will require more ammunition).

If you do not assign sustainment training frequencies to tasks, the average (i.e. once a month) will be assigned automatically.

In order to see the effects of changing training frequencies you should click on the "Apply" button, to apply the changes, and then the "Review" button on the "Assign Training Frequencies" dialog box. Once you have finished applying a training frequency, it is recorded for that particular Task or Military Occupational Specialty (MOS) and can be referred to or edited later by choosing "PTS" from the main menu item "Options."

It is important to note that any training frequency changes that you make may alter the stored accuracy, time, and/or probability values that IMPRINT has for that particular task or MOS, within your analysis. If you make training frequency changes, IMPRINT will produce a "Delta" Report that will show you how task performance has been changed. When this "Delta" Report is produced, you should print this report (either to a file or to your printer) in order to maintain a record of your changes. This record is important because you can make further changes in other places in IMPRINT. As these changes add up, it can be difficult, if not impossible, to regain your initial values. You should print any subsequent "Delta" Reports as well.

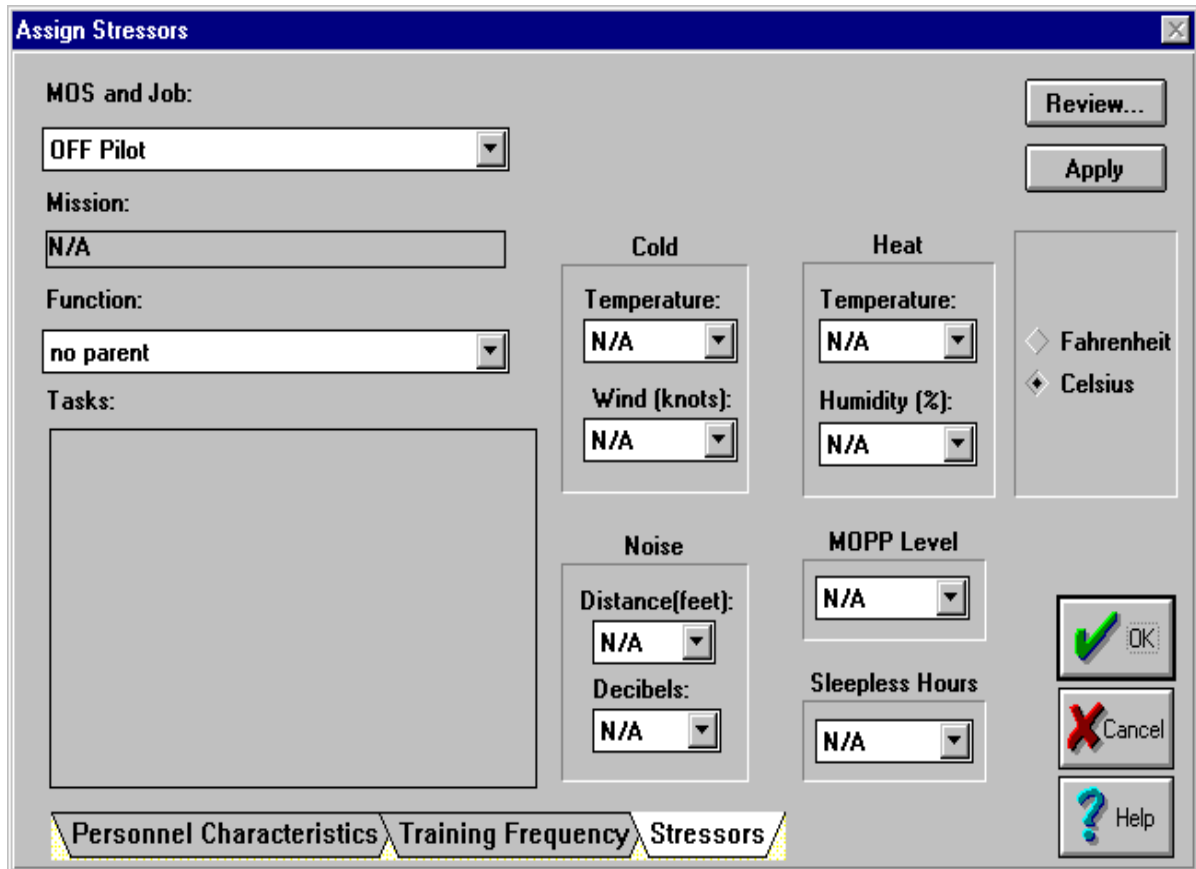
Apply Button

When clicked, this button applies the training frequency. You should realize that more frequent training will generally result in better performance within the MOS. Once you "Apply" your choices, you will see a report summarizing the new performance estimates and a "Delta" column that includes the impact that your changes have had on the MOST RECENT values for task accuracy, time, and the probability of achieving the minimum acceptable accuracy. So each time you press "Apply," the performance estimates will be a combined calculation based on all PTS settings so far, and the Delta values will show the amount of change from the immediately preceding "Apply" button click. If you want to "Unapply" your choices, you must go back to the combo boxes where the settings were changed, adjust them so that they are in the N/A or 0 levels, and "Apply" these values again.

Review Button

Click on this button to review any effects on task performance of applying training frequency changes to your tasks.

Stressors



The "Assign Stressors" dialog box is a tabbed interface with three tabs: "Personnel Characteristics", "Training Frequency", and "Stressors". The "Stressors" tab is currently selected. It contains several input fields and buttons. On the left, under "MOS and Job:", there is a dropdown menu showing "OFF Pilot". Below it, under "Mission:", is a text field with "N/A". Under "Function:", is a dropdown menu showing "no parent". Under "Tasks:", is a large empty text area. On the right, there are four stressor categories: "Cold", "Heat", "Noise", and "MOPP Level". Each category has a "Temperature:" field (all showing "N/A") and a "Wind (knots):" field (all showing "N/A"). The "Heat" category also has a "Humidity (%):" field (showing "N/A"). Below these are "Distance(feet):" (showing "N/A") and "Decibels:" (showing "N/A") for Noise, and "Sleepless Hours" (showing "N/A") for MOPP Level. At the bottom right, there are three buttons: "OK" (with a green checkmark), "Cancel" (with a red X), and "Help" (with a question mark). At the top right, there are "Review..." and "Apply" buttons. A temperature unit selector on the right shows "Fahrenheit" and "Celsius" with diamond-shaped selection indicators.

Figure 3-52. Assign Stressors

From the main menu item “Options” choose “PTS.” You can then choose whether you want to apply the impacts of stressors by individual task, or whether you want to apply them by MOS. Regardless of which you choose, you will be presented with the tabbed dialog shown above. Stressors are on the third tab.

This option allows you to review and change stressors. There are five different stressors that can be applied to tasks. They are: Mission Oriented Protective Posture (MOPP) gear for individual nuclear, biological, and chemical defense; heat; cold; noise; and sustained operations (i.e., lack of sleep). Stressors may be reviewed and changed for each individual task, one at a time, or, for an entire group of tasks, all at once. Depending upon the specifics of the task and MOS, adding stressors may decrease task accuracy and/or increase the time it takes to complete the task.

In order to see the effects of stressors you should apply them one at a time. To see the effects of applying stressors you should click on the “Review” button on the “Assign Stressors” dialog box. Once you have finished applying a stressor, it is recorded for that particular Task or Military Occupational Specialty (MOS) and can be referred to or edited

later by choosing "PTS" from the main menu item "Options."

It is important to note that any stressors that you apply may alter the stored accuracy, time, and/or probability values that IMPRINT has for that particular task or MOS, within your analysis. If you apply stressors, IMPRINT will produce a "Delta" Report that will show you how task performance has been changed. When this "Delta" Report is produced, you should print this report (either to a file or to your printer) in order to maintain a record of your changes. This record is important because you can make further changes in other places in IMPRINT. As these changes add up, it can be difficult, if not impossible, to regain your initial values. You should print any subsequent "Delta" Reports as well.

The table below indicates the impact of stressors by taxon.

TAXON	MOPP	Heat	Cold	Noise	Sleepless Hours
Visual	t	A	T		
Numerical		A			TA
Cognitive		A			TA
Fine Motor Discrete	T	A	T		
Fine Motor Continuous					
Gross Motor Light	T		T		
Gross Motor Heavy					
Commo (Read & Write)		A			
Commo (Oral)	T	A		A	

T = Affects task time. A = Affects task accuracy TA = Affects both

If you apply more than one stressor to the same task, then a power function is applied. This means that the most severe stressor will have full effect, and the others have less. More information regarding the relevant calculations can be found in Adkins and Dahl (1993).

Noise

This option allows you to change the decibel level (at the ear) and the distance between communicators for the environment in which individuals are performing operator and maintainer tasks. Stressors may be reviewed and changed for each individual task, one at a time, or, for an entire group of tasks, all at once. Depending upon the specifics of the task and MOS, adding stressors may decrease task accuracy and/or increase the time it takes to complete the task.

Heat

This option allows you to change the temperature and humidity for the environment in which individuals are performing operator and maintainer tasks.

Cold

This option allows you to change the temperature and wind speed for the environment in which individuals are performing operator and maintainer tasks.

Temperature Setting

Clicking on the Fahrenheit radio button changes all temperature related data to the Fahrenheit scale. Clicking on the Celsius radio button changes all temperature related data to the Celsius scale.

Sleepless Hours

This option allows you to change the hours last slept for individuals that are performing operator and maintainer tasks.

Apply Button

When clicked, this button applies the chosen ASVAB composite cutoff score, stressor combination, or training frequency. You should realize that a higher cutoff score will generally result in better performance within the MOS; however, there will be fewer people available that can attain the higher cutoff score. Once you "Apply" your choices, you will see a report summarizing the new performance estimates and a "Delta" column that includes the impact that your changes have had on the MOST RECENT values for task accuracy, time, and the probability of achieving the minimum acceptable accuracy. So each time you press "Apply," the performance estimates will be a combined calculation based on all PTS settings so far, and the Delta values will show the amount of change from the immediately preceding "Apply" button click. If you want to "Unapply" your choices, you must go back to the combo boxes where the settings were changed, adjust them so that they are in the N/A or 0 levels, and "Apply" these values again.

Review Button

Clicking on this button allows you to review any effects on task performance of applying stressors.

Review Function Data

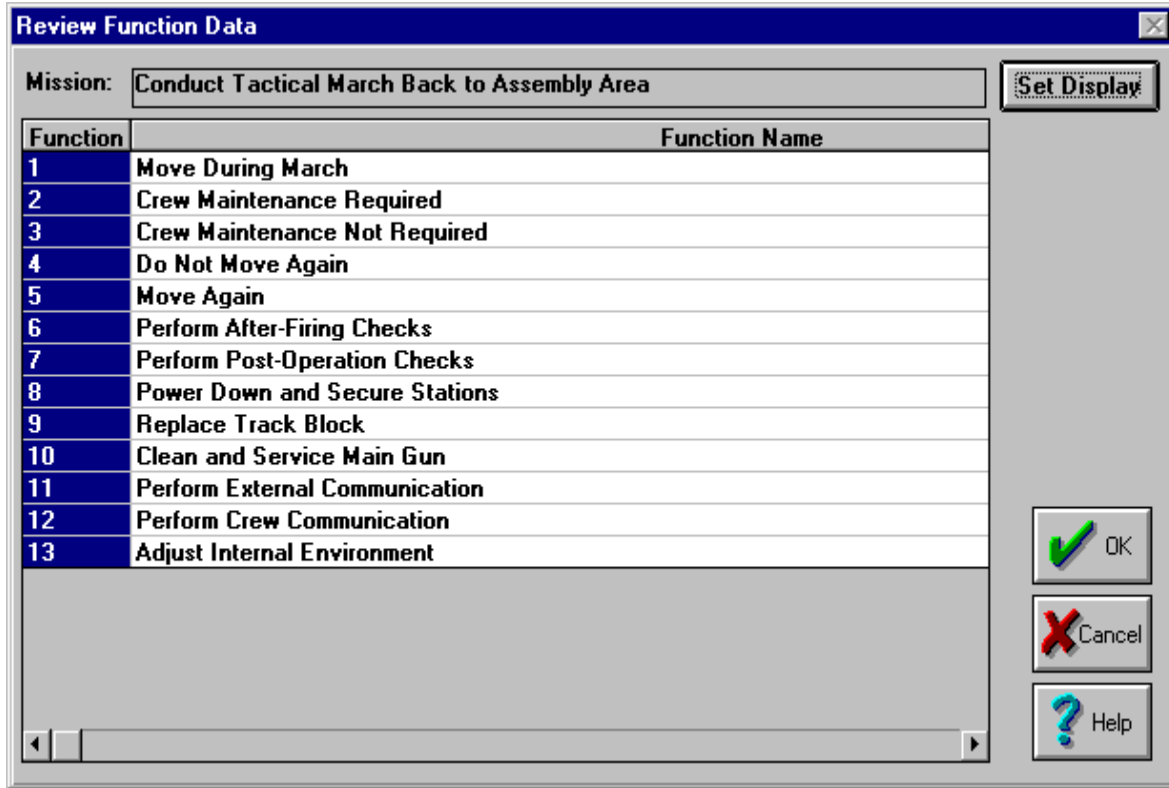


Figure 3-53. Review Function Data

The purpose of this spreadsheet is to enable you to view all the function data in a tabular format. These data are sorted in order of increasing function identification numbers. The spreadsheet scrolls left and right so that you can view all the columns. Also, you can change the widths of the columns by moving your cursor to the row that includes the column names. Then click and hold the button down on the divisions between columns, and slide the cursor left or right while holding the button down to resize the column.

You can not edit all the columns on this display. However, you can change the function time standard and the function criterion data element values.

You can use the standard Windows shortcut editing keys to paste data into this spreadsheet. This is handy if you have entered the data in an application like Excel. You just need to be sure that the columns in your source spreadsheet are in the same order and each column is in the same format (e.g., 00:00:00.00 for time values) as IMPRINT expects. Then, go to your application and select the data that you want to paste into IMPRINT and copy it to the clipboard, using Cntrl-C. Then, open the "Review" spreadsheet, select the area into which you want to paste the data, and press Cntrl-V. Be sure to double-check that the data are in the cells that you want.

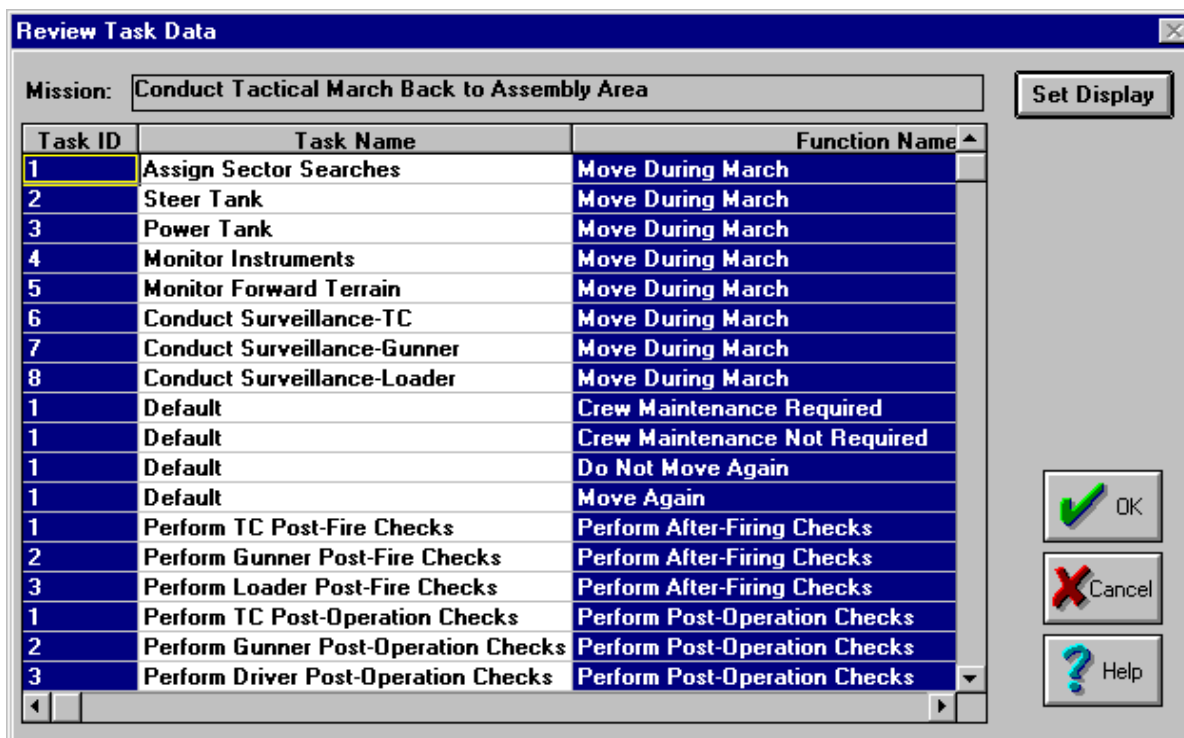
Set Display Button

As you can see, there are many more columns on the spreadsheet than will fit into the workspace window. You can choose to display selected columns to customize the

display for your needs by clicking on the Set Display button. You can then select the columns you wish to display.

Review Task Data

Operator



Task ID	Task Name	Function Name
1	Assign Sector Searches	Move During March
2	Steer Tank	Move During March
3	Power Tank	Move During March
4	Monitor Instruments	Move During March
5	Monitor Forward Terrain	Move During March
6	Conduct Surveillance-TC	Move During March
7	Conduct Surveillance-Gunner	Move During March
8	Conduct Surveillance-Loader	Move During March
1	Default	Crew Maintenance Required
1	Default	Crew Maintenance Not Required
1	Default	Do Not Move Again
1	Default	Move Again
1	Perform TC Post-Fire Checks	Perform After-Firing Checks
2	Perform Gunner Post-Fire Checks	Perform After-Firing Checks
3	Perform Loader Post-Fire Checks	Perform After-Firing Checks
1	Perform TC Post-Operation Checks	Perform Post-Operation Checks
2	Perform Gunner Post-Operation Checks	Perform Post-Operation Checks
3	Perform Driver Post-Operation Checks	Perform Post-Operation Checks

Figure 3-54. Review Task Data

The purpose of this spreadsheet is to enable you to view all the task data in a tabular format. These data are sorted in order of increasing function and task identification numbers. The spreadsheet scrolls left and right so that you can view all the columns. Also, you can change the widths of the columns by moving your cursor to the row that includes the column names. Then click and hold the button down on the divisions between columns, and slide the cursor left or right while holding the button down to resize the column.

You can not edit all the columns on this display. For instance, you can not change the Task ID or the parent function. However, you can change most of the task performance data.

You can use the standard Windows shortcut editing keys to paste data into this spreadsheet. This is handy if you have entered the data in an application like Excel. You just need to be sure that the columns in your source spreadsheet are in the same order and each column is in the same format (e.g., 00:00:00.00 for time values) as IMPRINT

expects. Then, go to your application and select the data that you want to paste into IMPRINT and copy it to the clipboard, using Cntrl-C. Then, open the "Review" spreadsheet, select the area into which you want to paste the data, and press Cntrl-V. Be sure to double-check that the data are in the cells that you want.

Set Display Button

As you can see, there are many more columns on the spreadsheet than will fit into the workspace window. You can choose to display selected columns to customize the display for your needs by clicking on the Set Display button. You can then select the columns you wish to display.

Maintainer

Review Maintainer Task Data									
Subsys	Equip	Compone	Action	Mai	Org Level	MOS	Gra	# (MOS 1)	
Engine	Mobil	Diesel Eng	Adjust & R	Preve	DS	63H	20	1	
Engine	Mobil	Diesel Eng	Inspect	Preve	GS	63H	20	1	
Engine	Mobil	Diesel Eng	Remove &	Preve	Unit	63D	20	1	
Engine	Mobil	Flywheel A	Remove &	Preve	GS	63H	20	1	
Engine	Mobil	Valves, Ca	Adjust & R	Preve	Unit	63D	20	1	
Engine	Mobil	Lubrication	Adjust & R	Preve	DS	63H	20	1	
Engine	Mobil	Lubrication	Remove &	Preve	Unit	63D	20	1	
Engine	Mobil	Manifolds	Adjust & R	Preve	DS	63H	20	1	
Engine	Mobil	Manifolds	Remove &	Preve	Unit	63D	20	1	
Engine	Mobil	Engine - ot	Adjust & R	Preve	GS	63H	20	1	
Engine	Mobil	Engine - ot	Inspect	Preve	DS	63H	20	1	
Engine	Mobil	Engine - ot	Remove &	Preve	Unit	63D	20	1	
Engine	Mobil	Engine - pr	Adjust & R	Corre	Unit	63D	20	1	
Engine	Mobil	Accessory	Remove &	Preve	Unit	63D	20	1	
Fuel	Mobil	Fuel Inject	Adjust & R	Preve	Unit	63D	20	1	
Fuel	Mobil	Fuel Inject	Inspect	Preve	Unit	63D	20	1	
Fuel	Mobil	Fuel Inject	Remove &	Preve	Unit	63D	20	1	
Fuel	Mobil	Fuel Pump	Adjust & R	Preve	Unit	63D	20	1	
Fuel	Mobil	Fuel Pump	Remove &	Preve	Unit	63D	20	1	
Fuel	Mobil	Air Cleaner	Remove &	Preve	Unit	63D	20	1	

Figure 3-55. Review Maintainer Task Data

The purpose of this spreadsheet is to enable you to view all the maintenance task data in a tabular format. These data are sorted in alphabetical order by subsystem. The spreadsheet scrolls left and right so that you can view all the columns. Also, you can change the widths of the columns by moving your cursor to the row that includes the column names. Then click and hold the button down on the divisions between columns, and slide the cursor left or right while holding the button down to resize the column.

You can not edit all the columns on this display. For instance, you can not change the

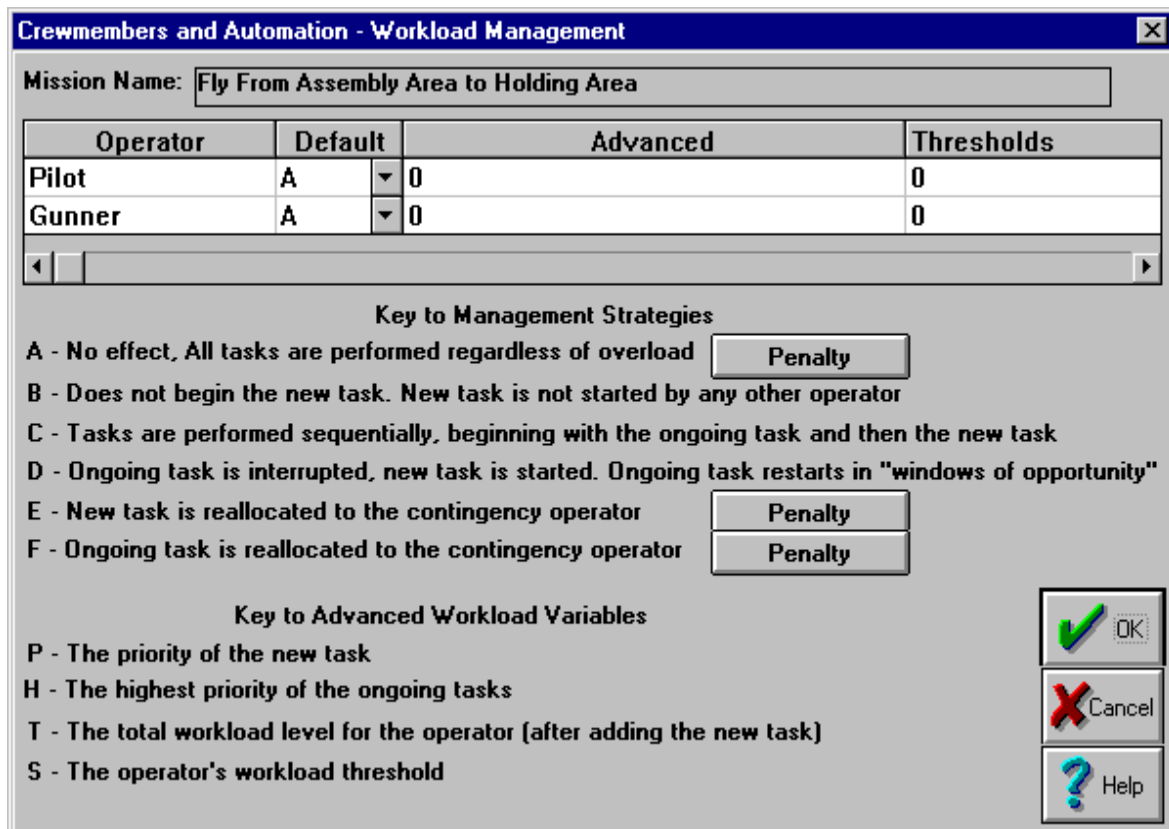
Subsystem Name, Component Name, Maintenance Task, and Maintenance Type (Preventive or Corrective). However, you can change most of the maintenance task performance data.

You can use the standard Windows shortcut editing keys to paste data into this spreadsheet. This is handy if you have entered the data in an application like Excel. You just need to be sure that the columns in your source spreadsheet are in the same order and each column is in the same format (e.g., 00:00:00.00 for time values) as IMPRINT expects. Then, go to your application and select the data that you want to paste into IMPRINT and copy it to the clipboard, using Cntrl-C. Then, open the "Review" spreadsheet, select the area into which you want to paste the data, and press Cntrl-V. Be sure to double-check that the data are in the cells that you want.

Set Display Button

As you can see, there are many more columns on the spreadsheet than will fit into the workspace window. You can choose to display selected columns to customize the display for your needs by clicking on the Set Display button. You can then select the columns you wish to display.

Workload Management



Crewmembers and Automation - Workload Management

Mission Name: Fly From Assembly Area to Holding Area

Operator	Default	Advanced	Thresholds
Pilot	A	0	0
Gunner	A	0	0

Key to Management Strategies

- A - No effect, All tasks are performed regardless of overload Penalty
- B - Does not begin the new task. New task is not started by any other operator
- C - Tasks are performed sequentially, beginning with the ongoing task and then the new task
- D - Ongoing task is interrupted, new task is started. Ongoing task restarts in "windows of opportunity"
- E - New task is reallocated to the contingency operator Penalty
- F - Ongoing task is reallocated to the contingency operator Penalty

Key to Advanced Workload Variables

- P - The priority of the new task
- H - The highest priority of the ongoing tasks
- T - The total workload level for the operator (after adding the new task)
- S - The operator's workload threshold

OK Cancel Help

Figure 3-56. Crewmembers and Automation - Workload Management

Operator workload management strategies help you model realistic operator actions under conditions of workload overload. This is only applicable to Advanced missions. There are six possible management strategies in IMPRINT. One of the strategies may be implemented when an operator's workload level exceeds his workload threshold.

The six possible strategies are:

- A. No Effect. The overloaded operator attempts to accomplish all tasks regardless of the overload condition.
- B. The overloaded operator does not begin the new task that will lead to overload.
- C. The overloaded operator performs the tasks sequentially.
- D. The overloaded operator interrupts an ongoing task, and accepts the new task. The operator attempts to take advantage of subsequent lower workload levels to resume the task.
- E. The overloaded operator re-allocates the new task to the contingency operator.
- F. The overloaded operator re-allocates an ongoing task to the contingency operator.

Each crew member must be assigned one default strategy to describe his actions under overload conditions. You can also assign advanced strategies to identify conditions under which other strategies would be implemented. The advanced strategies are optional.

During mission execution, if adding a new task causes the operator to surpass his workload threshold the management strategies will be evaluated. If none of the advanced strategies evaluate to 'True' or if there are no advanced strategies, the default strategy is implemented.

The Workload Management Window displays the crew member or device names in one column, the default management in another, advanced management strategies in a third column, and workload thresholds in the last column. Automation devices do not have management strategies associated with them.

To specify a default strategy, click on the drop box arrow in the Default field for an operator and select one of the strategies (A-F).

To specify advanced strategies, click in the Advanced field for an operator and enter algebraic expressions describing the advanced workload strategies for that operator.

To set the workload threshold level for an operator, click in the "Threshold" column and enter a numeric value to represent the workload threshold.

Advanced Workload Management Strategies

There are six possible management strategies in IMPRINT. One of the strategies may be implemented when an operator's workload level exceeds his workload threshold. The six possible strategies are:

- A. No Effect. The overloaded operator attempts to accomplish all tasks regardless of the overload condition.
- B. The overloaded operator does not begin the new task that will lead to overload.
- C. The overloaded operator performs the tasks sequentially.
- D. The overloaded operator interrupts an ongoing task, and accepts the new task. The operator attempts to take advantage of subsequent lower workload levels to resume the task.
- E. The overloaded operator re-allocates the new task to the contingency operator.
- F. The overloaded operator re-allocates an ongoing task to the contingency operator.

The Workload Management window displays the available strategies and a list of variables you can use to build logical expressions. The variables are:

A-F - the workload management strategy
P - the new task's priority
H - the priority of the highest ongoing task
T - the total workload level for the operator
S - the operator's workload threshold level

Build expressions by placing the mouse cursor in the entry area. The cursor will change from an arrow to an I-beam. Build logical statements using the variables, workload management strategies, and operators in the set ($=$, $:=$, $<$, $>$, $+$, $-$, $*$, $/$, $|$, $\&$) to develop "if-then-else" expressions. For example, if $P \leq 2 \ \& \ H > 2$ then A; is a valid expression. The "then" and "else" portions must be followed by one of the letters A-F that denote the management strategies. The "else" portion is optional. The "if" portion will consist of combinations of the variables P, H, T, and S, and the arithmetic operators.

The expressions will be evaluated in overload situations.

From the Workload Threshold column you can set a workload threshold for each crewmember in the mission. Automation devices do not have workload thresholds. It is assumed that beyond the threshold, the operator is overloaded. The overall threshold is defined in terms of the total momentary workload index or score. When workload rises above the threshold during the simulation, IMPRINT selects and applies a workload management strategy.

The Workload Management Window displays each of the crew member or device names.

Advanced Workload Threshold

To set the threshold, click in the "Thresholds" field for an operator. Use the numeric, arrow, backspace, and delete keys to enter/edit the threshold value. The workload threshold must be a number between 0 and 100.

Advanced Workload Penalties

IMPRINT allows you to specify any time and accuracy penalties related to employing certain workload management strategies. You will be able to make entries for time degradation and for accuracy degradation to be applied to tasks that are reallocated during model execution. You will also be able to enter a time and accuracy degradation percentage to be applied when the operator attempts to perform all tasks regardless of the overload situation.

To set the penalties: Click the “High Workload” button on the Workload Management window. IMPRINT then displays the High Workload Penalties window. The window displays any previously defined percentage degradations for time and accuracy for the appropriate workload management strategy. To enter the degradations: position the mouse cursor in the field you wish to edit the percentage and edit a percentage degradation between 0 and 100 using the arrow, Del, Backspace, and numeric keys.

Workload and Crewstation Parameters

The options under this menu item are only available for Advanced Missions.

Define Resources and Interfaces

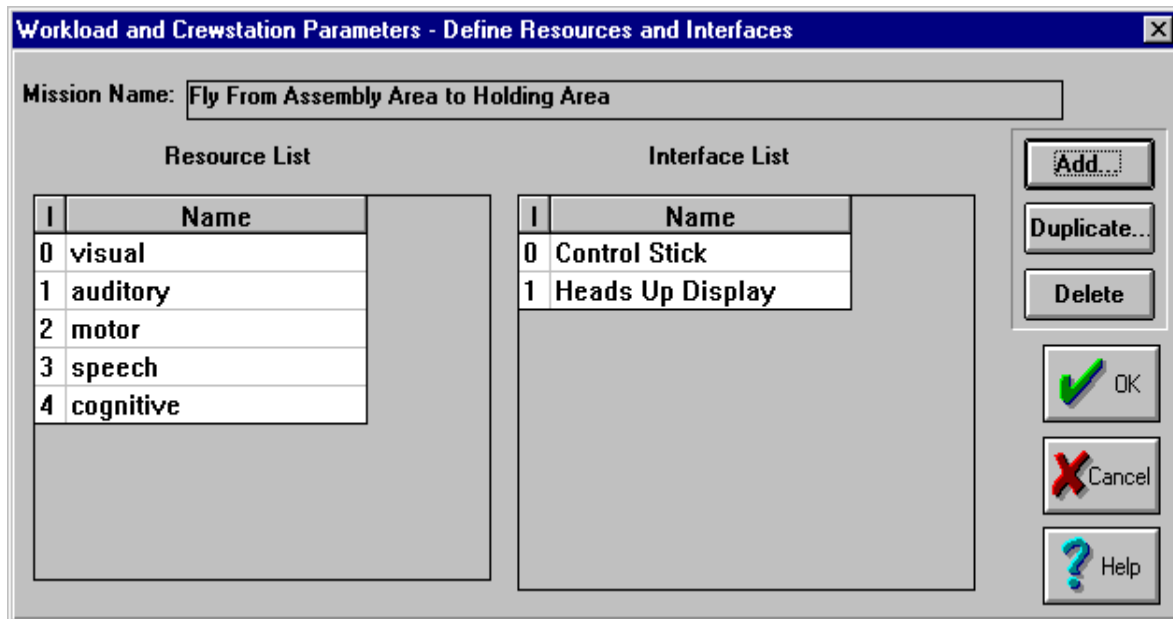


Figure 3-57. Define Resources and Interfaces

This is the first step in the process of identifying workload parameters for an Advanced Mission. This interface will only be available if you have opened an Advanced Mission from under the Define Mission menu item.

Define the resources and interfaces used by the operators in the mission by selecting “Workload and Crewstation Parameters” under the “Options” menu, then selecting

“Define Resources and Interfaces“ from the cascading menu. The Crewstation Parameters - Define Resources and Interfaces window shows the Resource List on the left side and the Interface List on the right. IMPRINT displays five default resources: visual, auditory, motor, speech, and cognitive. You can add to the list and delete resources from the list, however, if you define additional resources IMPRINT will not be able to help you assign task demand or conflict values for those resources. You also need to develop the interface list for your mission. Interfaces are controls and displays that the operator utilizes to perform the tasks in the mission.

Add Resources & Interfaces

The Add, Duplicate and Delete Buttons are used to change the resources and interfaces that you want to consider in your workload analysis. Each resource and interface must have a unique name. To add a resource or interface, first click anywhere in the list, then click on the button you want.

To enter the name, click in the appropriate name field. Use alphanumeric, arrow, backspace, and delete keys to enter the name. Resource names can be up to 12 characters in length. Interface names can be up to 16 characters in length.

Resource List

Five default human resources are provided within IMPRINT. You can add more resources to the list if you desire. Each resource must have a unique name. To add a resource, click anywhere in the resource list, then click on the Add Button.

To enter the name, click in the resource name field. Use alphanumeric, arrow, backspace, and delete keys to enter the name. Resource names can be up to 12 characters in length.

Interface List

The Add button is used to add new interfaces that will be utilized in performing tasks in your advanced mission. Each interface must have a unique name. To add an interface, click anywhere in the interface list, then click on the Add Button.

To enter the name, click in the interface name field. Use alphanumeric, arrow, backspace, and delete keys to enter the name. Interface names can be up to 16 characters in length.

Define Resource/Interface Channels

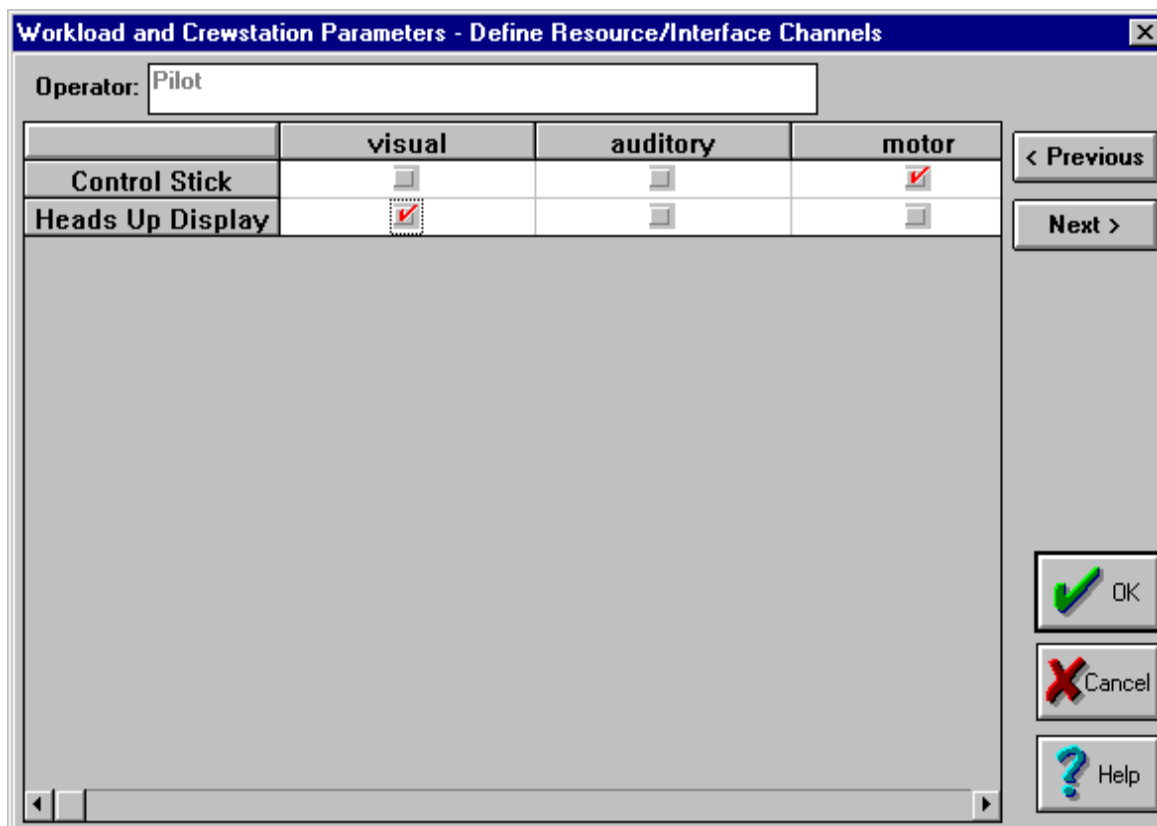


Figure 3-58. Define Resource/Interface Channels

Define the resource/interface channels for each crew member in the mission by selecting the “Define Resource/Interface Channels” from the cascading menu under the Options menu and the Workload and Crewstation Parameters menu item. This is only available if you have opened an Advanced Mission. For each crew member in the mission, you will form pairs between the resources and interfaces you identified under Define Resources and Interfaces.

This interface is a large matrix with interfaces down the first column and the resources across the top row. The cells are shown as boxes. Any previous resource/interface designations are indicated by checks in the cells. The spreadsheet scrolls left and right and up and down if necessary.

To mark or unmark a resource/interface channel, click on the cell in the row and column corresponding to the interface name and the resource name. IMPRINT will change marked cells to unmarked cells and vice versa. You can assign each interface to up to five resources by marking cells in the spreadsheet.

For every interface that the selected crew member utilizes in performing either primary or contingency tasks you should assign at least one resource.

Once you have assigned the resource interface pairs for one operator you can select

another operator to assign channels to using the “Next” and “Prev” buttons.

Assign R/I Channels to Tasks

Workload and Crewstation Parameters - Assign Resource Interface Channels to Tasks

Operator:

Function/Task	visual/Heads Up	motor/Control Stick
Plan Mission/Receive Mission	<input type="checkbox"/>	<input type="checkbox"/>
Plan Mission/Receive Mission	<input type="checkbox"/>	<input type="checkbox"/>
Plan Mission/Start Map Recon	<input type="checkbox"/>	<input type="checkbox"/>
Plan Mission/Complete Map Recon	<input type="checkbox"/>	<input type="checkbox"/>
Plan Mission/Complete Map Recon	<input type="checkbox"/>	<input type="checkbox"/>
Plan Mission/End Map Recon	<input type="checkbox"/>	<input type="checkbox"/>
Plan Mission/Complete Flight	<input type="checkbox"/>	<input type="checkbox"/>
Plan Mission/Brief Crew	<input type="checkbox"/>	<input type="checkbox"/>
Plan Mission/Receive Weather	<input type="checkbox"/>	<input type="checkbox"/>
Prepare Performance Planning	<input type="checkbox"/>	<input type="checkbox"/>
Prepare Performance Planning	<input type="checkbox"/>	<input type="checkbox"/>
Prepare Weight and Balance	<input type="checkbox"/>	<input type="checkbox"/>
Prepare Weight and Balance	<input type="checkbox"/>	<input type="checkbox"/>
Conduct Exterior Cockpit Check	<input type="checkbox"/>	<input type="checkbox"/>
Conduct Exterior Cockpit Check	<input type="checkbox"/>	<input type="checkbox"/>

Navigation buttons: < Previous, Next >, OK, Cancel, ? Help

Figure 3-59. Assign Resource Interface Channels to Tasks

Assign the resource/interface channels to tasks for each crew member in the mission by selecting “Workload and Crewstation Parameters” under the “Options” menu, then selecting “Assign R/I Channels to Tasks” from the cascading menu. This is only available if you have opened an Advanced Mission. For each crew member in the mission, you will identify the resource/interface channels that are used in performing each task. Each task may require more than one resource/interface channel. Your entries will be used to structure the multiple resource theory workload analysis performed by IMPRINT during model execution.

The window displays a spreadsheet interface with task names displayed down the left most column and resource/interface channels displayed across the top. The tasks are grouped by function and the channels are grouped by resource. Only those tasks that were assigned to the crewmember as either a primary task or a contingency task are displayed. The cells are shown as check boxes. Any previous task and channel assignments are indicated by check marks in the cells. The spreadsheet scrolls left and right and up and down if necessary.

To mark or unmark a channel as being utilized when the operator is performing a task, click on the cell in the row and column corresponding to the task name and the channel name, respectively. IMPRINT will change an unassigned task/channel to an assigned task/channel and vice versa. Each task can be assigned to up to five resource/interface channels.

Once every task has been assigned to at least one resource/interface channel, you can select another operator using the “Prev” and “Next” buttons.

Assign Single Task Demand Values

Workload and Crewstation Parameters - Assign Single Task Demand Values

Operator:

Function/Task	visual/Heads Up	motor/Control Stick
Plan Mission/Receive Mission (0.00	0.00	
Plan Mission/Receive Mission (0.00	0.00	
Plan Mission/Start Map Recon	0.00	
Plan Mission/Complete Map Rec	0.00	
Plan Mission/Complete Map Rec	0.00	
Plan Mission/End Map Recon	0.00	
Plan Mission/Complete Flight Pl	0.00	
Plan Mission/Brief Crew		
Plan Mission/Receive Weather E	0.00	
Prepare Performance Planning C	0.00	
Prepare Performance Planning C	0.00	
Prepare Weight and Balance For	0.00	
Prepare Weight and Balance For	0.00	
Conduct Exterior Cockpit Check/S		
Conduct Exterior Cockpit Check/F		

< Previous

Next >

OK

Cancel

Help

Figure 3-60. Assign Single Task Demand Values

Define the single task demand values for each crew member in the mission by selecting “Workload and Crewstation Parameters” under the “Options” menu, and then selecting “Assign Single Task Demand Values” from the cascading menu. This is only available if you have opened an Advanced Mission.

For each crew member in the mission you will enter single task demand values. These values will be used to compute the first order workload components during model execution. The values should indicate the relative demand on each channel when performing a task.

The window displays a spreadsheet with the task names displayed down the left most column and the resource/interface channels displayed across the top. The tasks are grouped by function and the channels grouped by resource. Only those tasks that were assigned to the crew member as either a primary or contingency task are displayed. Cells that require a demand value to be entered are shown as boxes. Any demand values previously entered are displayed in the cells. The default demand value is zero. The spreadsheet scrolls left and right and up and down if necessary.

To enter a demand value automatically, double click the mouse in the cell that corresponds to the desired task and channel. Note: Automatic entry can only be used if the channel involves one of the five default resources (visual, auditory, motor, speech, or cognitive). If you defined resources in addition to the default resources, you will not have the automatic entry option, you will have to manually enter the demand value. In automatic mode, IMPRINT recommends a demand value. In manual mode, you must enter a demand value.

To enter a demand value manually, click once in the demand field and use the numeric, backspace, and delete keys to manually enter a value.

Auditory Automatic Single Task Demand Entry

For each crew member in an Advanced Mission, you will enter single task demand values. These values will be used to compute the first order workload components during model execution. The values should indicate the relative demand on each channel when performing a task.

IMPRINT can help you by suggesting what the single task demand for tasks that utilize the auditory resource should be based upon your input regarding the nature of the task. The auditory parameter is needed for IMPRINT to automatically assign a demand value. The nature of demand parameter is the type of auditory involvement required by the operator to perform the task.

IMPRINT assigns a demand value based upon the nature of demand selected as follows:

Nature of the Demand Descriptors	Demand Value
Detect/Register Sound (Detect Occurrence of Sound)	1.0
Orient to Sound (General Orientation/Attention)	2.0
Orient to Sound (Selective Orientation/Attention)	4.2
Verify Auditory Feedback (Detect Occurrence of Anticipated Sound)	4.3
Interpret Semantic Content (Speech) Simple 3 (1-2 words)	3.0
Interpret Semantic Content (Speech) Complex 6 (sentence)	6.0
Discriminate Sound Characteristics (Detect Auditory Differences)	6.6
Interpret Sound Patterns (pulse rates, etc.)	7.0

To select the desired parameter, click on the parameter field and select the option that best describes the auditory involvement for that task. Once you have selected a

parameter, click on the “OK” button. IMPRINT will display a demand value in the appropriate cell in the spreadsheet.

Cognitive Automatic Single Task Demand Entry

For each crew member in an Advanced Mission, you will enter single task demand values. These values will be used to compute the first order workload components during model execution. The values should indicate the relative demand on each channel when performing a task.

IMPRINT can help you by suggesting what the single task demand for tasks that utilize the cognitive resource should be based upon your input regarding the nature of the task. The cognitive parameter is needed for IMPRINT to automatically recommend a demand value. The nature of demand parameter is the type of cognitive involvement required for the operator to perform the task.

IMPRINT assigns a demand value based upon the nature of demand selected as follows:

The Nature of the Demand Descriptors	Demand Value
Automotive (Simple Association)	1.0
Alternative Selection	1.2
Signal/Sign Recognition	3.7
Evaluation/Judgment (Consider Single Aspect)	4.6
Encoding/Decoding, Recall	5.3
Evaluation/Judgment	6.8
Estimation, Calculation, Conversion	7.0
Rehearsal	5.0

To select the desired parameter, click on the parameter field and select the option that best describes the cognitive involvement for the task. Once you have selected a parameter, click on the “OK” button. IMPRINT will display a demand value in the appropriate cell in the spreadsheet.

Motor Automatic Single Task Demand Entry

For each crew member in an Advanced Mission, you will enter single task demand values. These values will be used to compute the first order workload components during model execution. The values should indicate the relative demand on each channel when performing a task.

IMPRINT can help you by suggesting what the single task demand for tasks that utilize the motor resource should be based upon your input regarding the nature of the task. The motor parameter is needed for IMPRINT to automatically recommend a demand value. The nature of demand parameter is the type of motor involvement required to perform the task.

IMPRINT assigns a demand value based upon the nature of demand selected as follows:

Nature of the Demand Descriptors	Demand Value
Discrete Actuation (Button, Toggle, Trigger)	2.2
Continuous Adjustive (Flight Control, Sensor Control)	2.6
Manipulative	4.6
Discrete Adjustive (Rotary, Vertical Thumb Wheel, Lever Position)	5.5
Symbolic Production (Writing)	6.5
Serial Discrete Manipulation (Keyboard)	7.0

To select a desired parameter, click on the parameter field and select the parameter that best describes the motor involvement for that task. Once you have selected a parameter, click on the “OK” button. IMPRINT will display the demand value in the appropriate cell in the spreadsheet.

Speech Automatic Single Task Demand Entry

For each crew member in an Advanced Mission, you will enter single task demand values. These values will be used to compute the first order workload components during model execution. The values should indicate the relative demand on each channel when performing a task.

IMPRINT can help you by suggesting what the single task demand for tasks that utilize the speech resource should be based upon your input regarding the nature of the task. The speech parameter is needed for IMPRINT to automatically recommend a demand value. This nature of demand parameter is the type of speech involvement required to perform the task.

There are two options for the speech parameter, whether the operator must say one or two words or an entire sentence. IMPRINT assigns the demand value depending on this parameter as follows:

The Nature of the Demand Descriptors	Demand Value
Simple (1-2 words)	2.0
Complex (sentence)	4.0

To select a desired parameter, click on the parameter field select the option that best describes the number of words the operator must say. Once you have selected a parameter, click on the “OK” button. IMPRINT will display the demand value in the appropriate cell in the spreadsheet.

Visual Automatic Single Task Demand Entry

For each crew member in an Advanced Mission, you will enter single task demand values. These values will be used to compute the first order workload components during

model execution. The values should indicate the relative demand on each channel when performing a task.

IMPRINT can help you by suggesting what the single task demand for tasks that utilize the visual resource should be based upon your input regarding the nature of the task. The visual parameters needed to automatically recommend a demand value are the Nature of the Demand and the Visual Device. The Nature of the Demand is the type of visual involvement required by the operator to perform the task. The Visual Device is whether the operator is aided or not aided (with or without Night Visual Goggles (NVG)).

IMPRINT assigns a demand value based upon the Nature of the Demand and Visual Device as follows:

Nature of the Demand Descriptors	Demand Value w/out NVG	Demand Value w/ NVG
Visually Register/Detect (Detect Occurrence of Image)	3.0	5.0
Visually Discriminate (Detect Visual Differences)	5.0	7.0
Visually Inspect/Check (Discrete Inspection/Static Condition)	3.0	5.0
Visually Locate/Align (Selective Orientation)	4.0	5.0
Visually Track/Follow (Maintain Orientation)	4.4	5.4
Visually Scan/Search Monitor (Continuous/Serial Inspection)	6.0	7.0
Visually Read (Symbol)	5.0	N/A

To select the desired parameters, click on the parameter field and then select the option that best describes the visual involvement for the task. Once you have selected the parameters, click on the “OK” button.

IMPRINT will display the demand value in the appropriate cell in the spreadsheet.

Assign Channel Conflict Values

Workload and Crewstation Parameters - Assign Channel Conflict Values

Operator:

Resource/Interface	visual/Heads Up	motor/Control
visual/Heads Up Display	0.80	0.10
motor/Control Stick		0.90

< Previous

Next >

OK

Cancel

Help

Figure 3-61. Assign Channel Conflict Values

Define the channel conflict values for each crew member in the Advanced mission by selecting “Workload and Crewstation Parameters” under the “Options” menu then selecting “Assign Channel Conflict Values” from the cascading menu. For each crew member in the mission you need to enter channel conflict values. These values will be used to compute the second and third order workload components during model execution. Conflict values range from 0.0 to 1.0. A conflict value of 0.0 means that the two channels do not interfere with each other at all. A conflict value of 1.0 means that the two channels cannot be utilized at the same time.

IMPRINT has two modes available to you for assigning the conflict values:

- 1) automatic mode - IMPRINT recommends a conflict value
- 2) manual mode - you enter a value from the keyboard

Automatic mode is only available for channels that utilize one of the five basic resources (visual, auditory, motor, speech, and cognitive). Channels that utilize other resources will have to have conflict values manually entered.

The Assign Channel Conflict Values window displays a spreadsheet with the resource/interface channels displayed both down the left column and across the top. The channels are grouped by resource. The interface names listed down the left column are displayed in boxes if they are potential candidates for automatic entry. The cells in the spreadsheet are displayed as boxes. Any previously defined conflict values are displayed in the cells. The default conflict value is 0.0.

To enter a conflict value in automatic mode, click on a interface name in the left column that is surrounded by a box.

To manually enter a conflict value, click on a cell in the spreadsheet.

Manual Channel Conflict Data Entry

For each crew member in the mission you will enter channel conflict values. These values will be used to compute the second and third order workload components during model execution. Conflict values range from 0.0 to 1.0. A conflict value of 0.0 means that the two channels do not interfere with each other at all. A conflict value of 1.0 means that the two channels cannot be utilized at the same time.

To manually enter a conflict value, click on the desired cell in the spreadsheet. Use the numeric, arrow, backspace, and delete keys to enter/edit the conflict value.

Automatic Auditory Channel Conflict Data Entry

Conflict values range from 0.0 to 1.0. A conflict value of 0.0 means that the two channels do not interfere with each other at all. A conflict value of 1.0 means that the two channels cannot be utilized at the same time.

IMPRINT can help you by suggesting what the channel conflict value for tasks that utilize the auditory resource should be based upon your input regarding the nature of the task.

For the auditory channel, you need to supply information on a parameter that is used to automatically compute a conflict value for auditory channels. The parameter is:

- 1) What is the normal content of this channel?

Clicking in the field next to the question will cause IMPRINT to change Tonal to Verbal or Verbal to Tonal.

Initial conflict values are computed as follows:

auditory/visual=0.2
auditory/auditory=0.7
auditory/motor=0.2
auditory/speech=0.4
auditory/cognitive=0.4

The initial values will then be modified by the following rules. Auditory/auditory conflicts are incremented by 0.1 if both interface channels are tonal and by 0.2 if both are verbal. Auditory/speech conflicts should be incremented by 0.2 if the auditory interface channel is verbal.

To save any changes and close the window, click on the “OK” button. IMPRINT will

display conflict values for that row of the spreadsheet and display the values in the cells.

Automatic Cognitive Channel Conflict Data Entry

IMPRINT can help you by suggesting what the channel conflict value for tasks that utilize the cognitive resource should be based upon your input regarding the nature of the task. For the cognitive channel you need to supply the following parameter in order to compute conflict values automatically.

- 1) Does this channel require spatial processing?

Clicking on the field will cause IMPRINT to change the answer from selected to deselected.

Initial conflict values are computed as follows:

cognitive/visual = 0.5
cognitive/auditory = 0.4
cognitive/motor = 0.1
cognitive/speech = 0.5
cognitive/cognitive = 0.7

The initial values will then be modified by the following rule. Cognitive/cognitive conflicts are incremented by 0.1 if one channel requires spatial processing and by 0.2 if both do.

To close the window and automatically compute conflict values, click on the “OK” button. IMPRINT will display conflict values for that row of the spreadsheet and display the values in the cells.

Automatic Motor Channel Conflict Data Entry

IMPRINT can help you by suggesting what the channel conflict value for tasks that utilize the motor resource should be based upon your input regarding the nature of the task. For the motor channel you need to supply parameters that are used to automatically compute a conflict value for motor channels. The parameters are:

- 1) This channel is activated by:
- 2) Does this channel carry verbal information?

Clicking in the field next to the first question will cause IMPRINT to display a list of potential activators for the channel, and next to the second question will cause the field to change from No to Yes or visa versa.

Initial conflict values are computed as follows:

motor/visual=.1

motor/auditory=.2
motor/motor=.7
motor/speech=.2
motor/cognitive=.1

If both channels carry verbal information, the value is incremented by .1.

Motor/motor interface conflict values are incremented by .1 if one channel can use either hand/foot, but prefers one over the other, and the other channel must use that hand/foot. Values are incremented by .2 if both channels must use the same hand/foot. If both require the head, increment by .2. If both carry verbal information, increment by .1.

To save any changes and close the window, click on the “OK” button. IMPRINT will display conflict values for that row of the spreadsheet and display the values in the cells.

Automatic Speech Channel Conflict Data Entry

IMPRINT can help you by suggesting what the channel conflict value for tasks that utilize the speech resource should be based upon your input regarding the nature of the task.

Speech channels do not require any parameters from you in order to compute conflict values automatically.

Initial conflict values are computed as follows:

speech/visual = 0.1
speech/auditory = 0.4
speech/motor = 0.2
speech/speech = 1.0
speech/cognitive = 0.5

The initial values will then be modified by the following rule. Speech/auditory conflicts are incremented by 0.2 if the auditory interface channel is verbal.

To close the window and automatically compute conflict values, click on the “OK” button. IMPRINT will display conflict values for that row of the spreadsheet and display the values in the cells.

Automatic Visual Channel Conflict Data Entry

Conflict values range from 0.0 to 1.0. A conflict value of 0.0 means that the two channels do not interfere with each other at all. A conflict value of 1.0 means that the two channels cannot be utilized at the same time.

IMPRINT can help you by suggesting what the channel conflict value for tasks that utilize the visual resource should be based upon your input regarding the nature of the task. For the visual channel you need to supply parameters that are used to automatically compute a

conflict value for visual channels. The parameters are:

- 1) Requires verbal information
- 2) Requires foveal fixation

Clicking in the field next to each question will cause the field to change from select or deselect it.

Initial conflict values are computed as follows:

visual/visual=0.7
visual/auditory=0.2
visual/motor=0.1
visual/speech=0.1
visual/cognitive=0.5.

To save any changes and close the window, click on the “OK” button. IMPRINT will display conflict values for that row of the spreadsheet and display the values in the cells.

Retrieve Micro Saint Results

This option enables you to import the results of an IMPRINT-compatible Micro Saint model into your IMPRINT database. This option is useful if you have previously exported IMPRINT data to Micro Saint and then used Micro Saint to make the model more complex. If you have adhered to the IMPRINT snapshot results conventions (by not deleting or changing any of the snapshots in the original exported model), then this import capability will reformat your results and place them into the database, attached to a system and operations mission of your choosing.

When you access this import capability, you will need to identify the location of your Micro Saint results files, as well as the existing system and mission to which you want to attach the results.

For more information on Micro Saint results files, please see your Micro Saint User’s Manual. Also, please note that this capability is only recommended for experienced users.

Send Model to Micro Saint

This option enables you to export an IMPRINT operations model to the commercial Micro Saint product.

This option is useful if you are an experienced Micro Saint modeler and you want to add more sophisticated modeling capabilities than are supported in IMPRINT. If you have adhered to the IMPRINT snapshot results by not deleting or changing any of the snapshots in the original exported model), then you will be able to use the import capability tool to reformat your results and place them into the database, attached to a

system and operations mission of your choosing.

When you access this export capability, you will need to identify which system and existing mission you want to export and where you want the Micro Saint model file to be saved.

For more information on Micro Saint's capabilities, please see your Micro Saint User's Manual. Also, please note that this capability is only recommended for experienced users.

Execute Menu

Operations Model

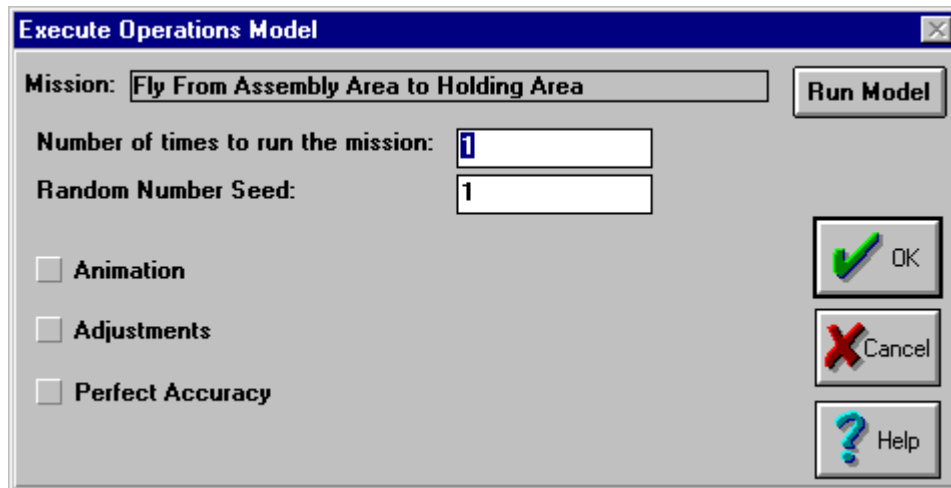


Figure 3-62. Execute Operations Model

To begin executing the model, choose the “Operations Model...” option from the “Execute” menu. When you make this menu selection, IMPRINT will load the data for the operations mission model and display the System Name along with your mission name.

You may then select the Number of Times to Run the Mission and the Random Number Seed that will be used. The default number of times to run the mission is one. If you would like to run a model more than one consecutive time, you can enter that number in this field. If you have a relatively short mission, you may want to run the model several times in order to be confident that the data you get from all of the runs is representative. One short run may, by chance, produce data that are not very typical. IMPRINT will automatically begin each run with a new random number seed.

There are several additional options from which to choose. You may select “Adjustments” to use the task times and accuracies that were adjusted as a result of the

combined applied Personnel Characteristics, Training Frequencies and Stressors. You can also turn animation on so that your network schematic is displayed as the model runs. Finally, you can set an option that will run the model with perfect accuracy. This is sometimes useful when debugging your mission model. For detailed information regarding how an Operations Model executes, please refer to Chapter 4 in this document.

Random Number Seed

IMPRINT will ask you to enter a random number seed. The random number seed is used to initialize a function that generates a random number. Throughout model execution, each new random number generated become the new random number seed. IMPRINT uses these random numbers to provide accurate statistical variance in the calculation of the actual times for task performance time and performance and the probabilistic paths taken through your mission network.

The same random number seed will always produce the same results for any particular mission. In other words, a given random number seed will always produce the same execution times and sequence of tasks each time the simulation model is executed, as long as the model itself doesn't change.

Operations Model Options

You may select to run the mission model with or without animation. If you check "animation," a schematic of your network will be displayed when the mission model is running. Current functions or tasks being executed will be indicated with flashing black and white nodes.

You may select to run the mission model with or without adjustments. If you check "Adjustments," any applications of stressors, training frequency, or personnel characteristics will be used to modify task times and accuracies. If you do not check adjustments, the mission model will be run with the original (or baseline) task times and accuracies.

Also, you can run your model with "perfect accuracy." This means that the model will be run with a 100% probability of success on each task.

Animation

You can use animation to be sure that the flow of your mission model is correct. If you select Animation, a task network that is very similar (but not exactly the same) of the one you built will be drawn. On the left hand side of the screen are a number of buttons. Use the Zoom In and Zoom Out buttons to change the magnification of the network.

As soon as the task network is displayed, the model will be running. Typically, it runs VERY quickly. They nodes in the model will be highlighted as they execute. You can use the "up" and "down" buttons at the top of the network diagram to traverse the hierarchy of your network.

If you want to pause and single step the execution of the model, so that you can more carefully and slowly trace the execution, then as soon as the model comes up, press "Cntrl P". This will pause model execution. Then, use "Cntrl T" to single step through the model. If you want the model to return to normal speed, press "Cntrl G".

User Snapshots

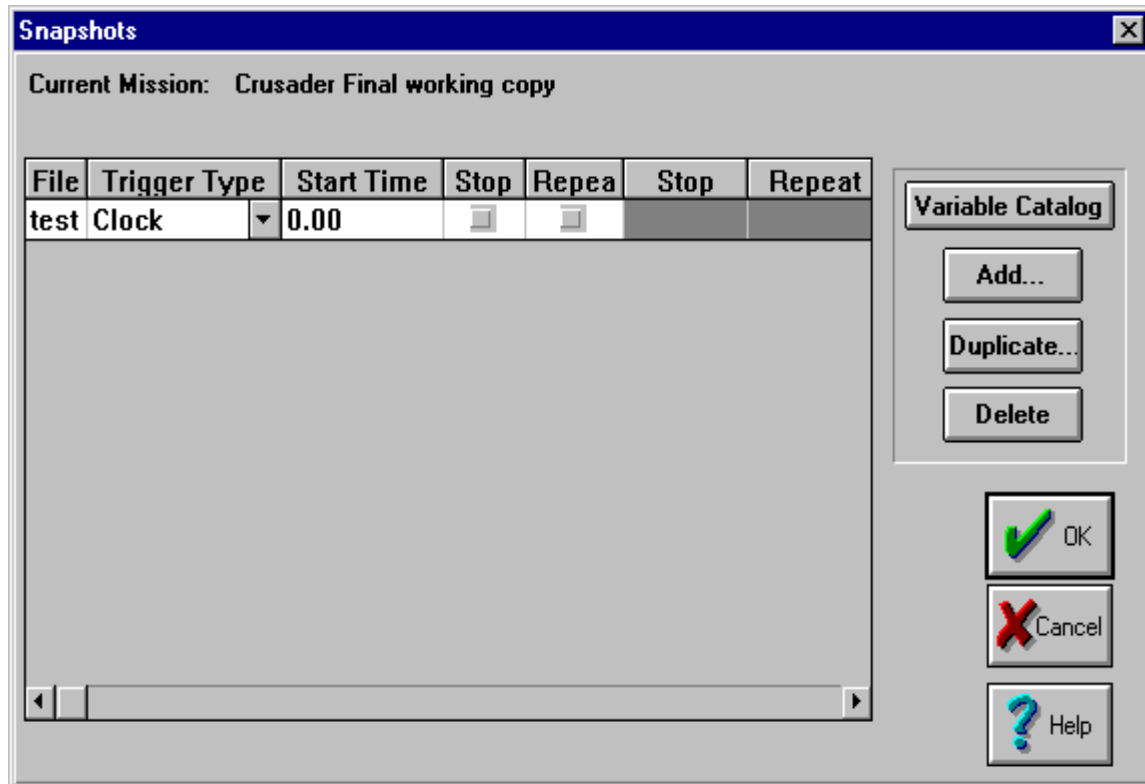


Figure 3-63. Snapshots

From the "User Snapshots" button on the "Execute" dialog, you can define custom data collection parameters for Advanced Missions. Snapshots provide a way for you to collect values of variables at specified points during model execution. IMPRINT has several built-in data collection capabilities. Data automatically collected by IMPRINT Advanced models include: workload levels for each operator, task status information (busy, not busy, suspended, stopped), and task failure information. You can use this optional capability to define custom data collection parameters. You can define new snapshot files, modify existing snapshot files, and delete existing snapshot files from this window.

Data collection snapshots can be triggered by clock times or model events. You can specify snapshots to occur at specific clock times (one-time or repeating), when a task begins or ends, or when the model run ends.

For each snapshot, the following information must be supplied:

- a name for the file in which the data will be stored
- the "trigger type" (End of Run, Clock, Begin Task, End Task)

- the name of the triggering function and task, if the snapshot has a task trigger
- the start time, stop time, and repeat interval, as applicable, if the snapshot has a clock trigger
- the names of the variables for which you want IMPRINT to record values

IMPRINT will save the snapshot information as ASCII text files that can be viewed from IMPRINT or from any text editor. In order to save the data, IMPRINT must be supplied with a name to store the data under. To enter a name for a snapshot file, click in the “Filename” field for the file, and enter a name in which the data will be stored (maximum of 8 characters). When the mission is executed, IMPRINT will create a file with that name and store the values of the specified variables.

To specify the trigger type: click on the drop down arrow in the “Trigger Type” field, Select the appropriate trigger from the list, if “Beg Task” or “End Task” is selected, IMPRINT will display the list of Functions and prompt you to select one, once a function is selected, IMPRINT will display the list of tasks from that function and prompt you to select the one that will trigger the snapshot. Based upon the trigger type selected, IMPRINT will enable or disable other parameters to be defined.

To specify the variables for which IMPRINT will store values: click on a filename from the list, click on the “Variables” button, (IMPRINT will then display the list of variables that have been defined for the mission), select variables to store by clicking on the name(s), select the “OK” button. If any variables selected are arrays, IMPRINT will display a “Array Variable Selection” window, from this window, identify which array dimensions to store then select the “OK” button.

Note: You will only be able to define a maximum of 12 snapshot files. This is due to the DOS restriction that only 16 files can be open at any one time. Depending on the number of tasks in your model, a minimum of four files are utilized by IMPRINT to generate the automatic data collection. The larger your mission, the fewer number of user snapshot files that can be defined.

Maintenance Model

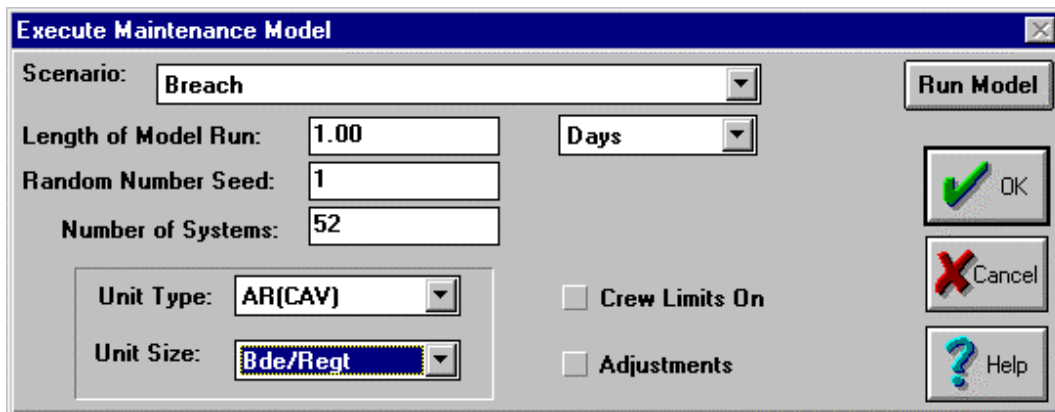


Figure 3-64. Execute Maintenance Model

To begin executing the maintenance model, choose the “Maintenance Model...” option from the “Execute” menu. When you make this menu selection, IMPRINT will load the data for the maintenance model and display the System Name along with a list of the scenarios currently in the working database for the system you selected.

You may then select the time period over which to execute your model and the Random Number Seed that will be used. The default time period is one day. You also can select the Number of Systems to run. The number of systems defaults to one.

You may select to run the maintenance model with or without adjustments. If you check "Adjustments" any applications of stressors, training frequency, or personnel characteristics will be used to modify Mean Time to Repair (MTTR) data for each task. If you do not check adjustments, the maintenance model will be run with the original (or baseline) MTTR data.

Finally, you may select to include Crew Size Limits.

To begin execution of the model click on the “Run Model” button. Chapter 5 of this document contains a detailed explanation of what occurs as the Maintenance model runs. Please refer to that chapter for more information.

Reports Menu

To review one or more of the many reports in IMPRINT click on “Reports” on the IMPRINT main menu. You will then be presented with a secondary menu from which you can select the type of report (e.g., Operations, Maintenance, Force Structure, etc.) to be reviewed. After selecting a type of report, you can then select an individual report to be reviewed. IMPRINT uses a report generator called Crystal Reports. This utility has its own interface and allows you to do things like export a report to another Windows application. The Crystal Reports interface appears when you select a report to be reviewed. This interface is shown in the following figure.

At the top of the report are buttons that you can use to page through the report. The printer icon sends the report to the printer you have identified under the Printer Setup item on the File menu. The envelope icon is used to export the contents of the report to another file. The combo box can be used to scale the report to a size that you can read.

You can display several reports at once, and they are presented in separate, independent windows. However, you must close all reports before executing the model again.

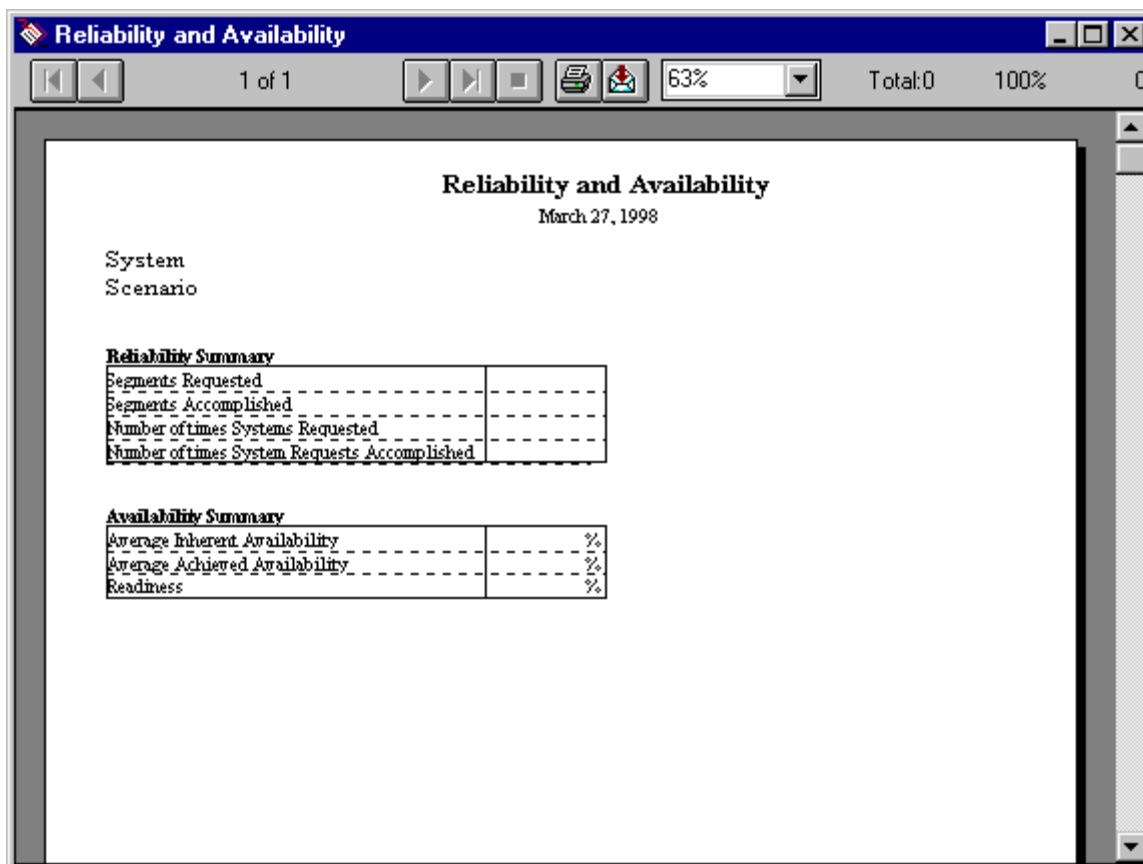


Figure 3-65. Sample Report

Exporting Report Data

IMPRINT uses a commercial tool called Crystal Reports to generate and display reports. When a report is displayed, you can choose to export the data to a file by clicking on the envelope icon in the tool bar, at the top of the report. You will then be able to select the output format you want. The current format options are:

- Character-separated values
- Comma-separated values
- Crystal Reports
- Data Interchange Format (DIF)
- Excel 2.1
- Excel 3.0
- Excel 4.0
- Lotus 1-2-3 (WK1)
- Lotus 1-2-3 (WK2)
- Lotus 1-2-3 (WKS)
- Record style (columns of values)
- Rich Text Format
- Tab-separated text
- Tab-separated values
- Text

Word for DOS document
Word for Windows document
WordPerfect document

After selecting a file format, you will be prompted to select the directory in which you want to have the new file saved.

Operations Model Results

VACP Model

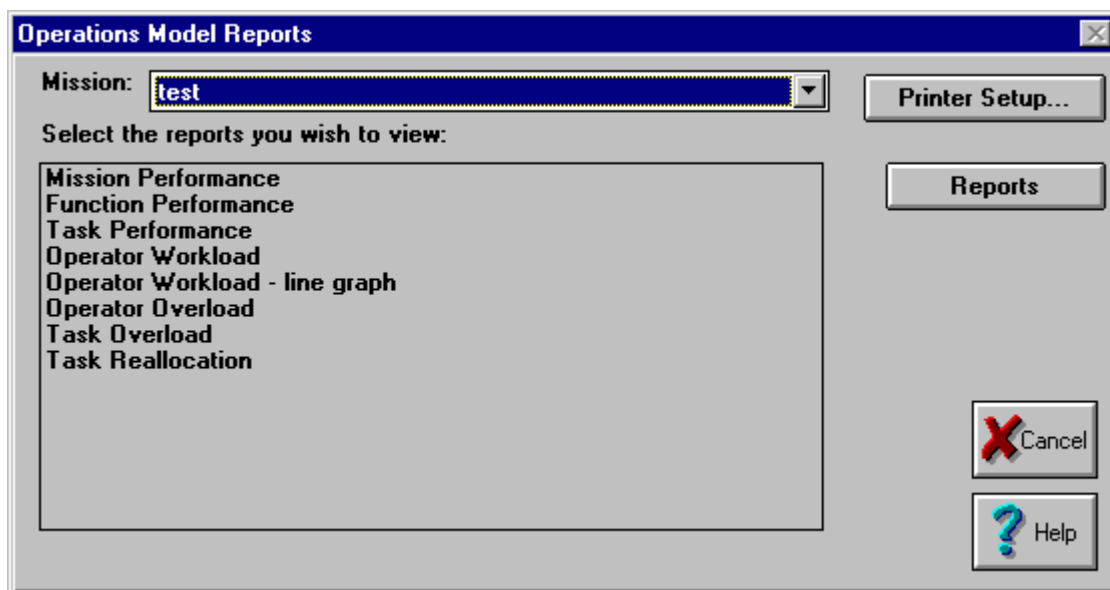


Figure 3-66. Operations Model Reports

There are several reports that are available after a VACP Mission has completed. To display reports, highlight the ones you want and click the "Reports" button.

The Mission Performance Report will give you the Mission Time Standard and the Achieved Mission Time. The Achieved Mission Time is the performance time that was simulated as a result of the individual tasks' performance times. If the Achieved Mission Time is less than or equal to the Mission Time Standard, you will also see a message that says the mission passed the requirement. If the Mission Time Standard is less than the Achieved Mission Time, then the mission failed its performance time standard. If you did not enter a time standard, it will default to zero. Therefore, it will probably cause the percentage of time you met the standard to be 0%.

The Function Performance Report includes a summary of each function that was performed, the number of times it was performed, and the minimum, maximum, mean and standard deviation of the performance times. This report also indicates the function performance time standard, and compares the results of the simulation to that standard. If

you did not enter a time standard, it will default to zero. Therefore, it will probably cause the percentage of time you met the standard to be 0%.

The Task Performance Report is a detailed report that provides output for each task in your mission model. The simulated (or predicted) performance time and accuracy are included on the report. The predicted values are compared to the task time standard and the percentage of occurrences in which the predicted time met the standard are reported. . If you did not enter a time standard, it will default to zero. Therefore, it will probably cause the percentage of time you met the standard to be 0%. This report also includes a summary of the performance accuracy that was predicted for each task, and the number of times that task failure led to mission failure.

The Operator Workload Report includes a listing of each operator's workload throughout the mission timeline. This report can easily be exported to Excel for graphing. Alternatively, you can use the Operator Workload Report - Line Graph option to get a simple graphical report.

The final three reports are associated with reporting operator overload, if any occurred during your mission.

The Operator Overload Report tells you the percentage of time each operator spent in an overload condition.

The Task Overload Report provides a summary of the number of times each task began, and the number of times the task began in an overload condition.

The Task Reallocation Report summarizes the result of any task reallocation.

Advanced Model

A number of separate performance reports are available after you execute an Advanced Mission. These can be found under the Reports menu and the Operations Model menu item. The reports include:

- Mission Performance Results
- Critical Path Summary
- Task Performance Summary
- Task Failure Summary
- Operator Activity Report
- Operator Workload Report
- Overload Report
- Channel Conflict Summary
- Task Timeline Chart
- Crewstation Workload

You can also export the data from your reports to other file formats. IMPRINT uses a

commercial tool called Crystal Reports to generate and display reports. When a report is displayed, you can choose to export the data to a file by clicking on the envelope icon in the tool bar. at the top of the report. You will then be able to select the output format you want.

Note: It is important that you realize that results from an Advanced Mission model are not stored in the IMPRINT database. Therefore, you should print the reports so that you can revisit them without re-executing the model. Otherwise, you will have to rerun the model to see the report for that mission.

Mission Performance Results

This report presents data on end-to-end mission performance time, target acquisition, and target engagements. Use this report as a quick look tool to verify the model executed successfully and the correct number of targets appeared.

The following information is displayed in the Mission Performance Summary window:

- End to End Mission Performance Time - this is the amount of time the mission executed
- Time at Mission Termination - this is the time at which the mission either completed or was aborted
- Cause of Mission Termination - there are two ways that a mission can terminate: 1) the mission completed normally, or 2) the mission was aborted due to a task failure
- The function in which the mission was aborted (if any) - if the cause of mission termination was mission abort, the function that caused the abort is displayed
- The task in which the mission was aborted (if any) - if the cause of mission termination was mission abort, the task that caused the abort is displayed
- Total # of targets appearing - this is the number of threat scenarios that occurred during the simulation
- Total # of targets acquired - this is the value of the variable "acquired" at the end of the simulation
- Total # of targets engaged - this is the value of the variable "engaged" at the end of the simulation

Critical Path Summary

The Critical Path Summary identifies the tasks in the mission that make up the critical path through the network. These tasks may have led to the mission performance time. Use it to identify a time flow impediment to the mission.

The report lists the following in temporal order (from time 0 to mission completion):

- function name - the function that the task is in
- task name - the name of the task that is on the critical path
- beginning time - the time that the task started

- ending time - the time that the task completed
- performance time - task end time minus task begin time
- suspension time - the amount of time that the task was suspended

Task Performance Summary

The Task Performance Report provides detailed information about task behavior during the mission. Use this report to review statistical data on task execution.

The Task Performance Report provides the following information;

- function/task names - the name of the functions and tasks in the mission
- task mean time - the average of task execution times
- variance - a measure of the difference in execution times (see a statistical handbook for more information)
- standard deviation - the square root of the variance
- sum of X - the sum of the execution times
- sum of X squared - the sum of execution times squared
- definition of task success - text field entered in Build Mission to describe task success
- number of times executed - number of the times the task was performed
- number of times successful - the number of times the task did not fail

Task Failure Summary

The Task Failure Summary provides information about task failure during the mission. Use this report to verify the consequences of failure for a task have been defined appropriately.

The Task Failure Summary provides the following information:

- function name - the function that the failed task is in
- task name - name of the task that failed
- time - time at which the failure occurred
- consequence of failure - the consequence that was applied

Operator Activity Report

The operator activity report provides you with a detailed description of a crewmember or device's activity during the simulation. Use this report to verify the actions are modeled appropriately.

The following information is displayed for the selected operator:

- function name - the name of the function that was performed
- task name - the name of the task within the function that was performed
- beginning time - the time at which the task started
- ending time - the time at which the task ended

The tasks are listed in time sequence, from the beginning of the mission to the end. Thus,

the report represents a chronological sequence of operator activity during the mission, including periods of inactivity.

Operator Workload Report

The Operator Workload report option allows you to view the operator workload data in either tabular or graphical form. The Report Display sub-option provides the workload profile for each operator in a tabular format. The Graph sub-option displays the workload profiles on an x-y graph. You can use either form of this report to quickly identify points of high workload.

The workload is displayed as a step graph on an x-y axis. The x (horizontal) axis represents time and the y (vertical) axis represents the workload index. Each operator's workload profile is displayed in a different color. The key is located in the window.

The tabular report shows:

- mission time
- operators 0 through 9
- operator name

The time scale ranges from time 0 through mission completion time. You can obtain a printed copy of the report by selecting the Print icon.

Overload Report

The Overload Report provides a description of the events surrounding any points of operator workload overload. It is useful in diagnosing the causes of overload conditions.

The Overload Report displays the following information:

- time of overload
- operator affected
- the operator's workload threshold
- the total workload level
- the sum of single task demands
- the total intra channel conflict demand
- the total inter channel conflict demand
- a list of functions and tasks executing at the time of overload

Channel Conflict Summary

The Channel Conflict Summary shows you information about the conflict between different resource/interface channels. You can use this report to compare missions and determine circumstances where an operator is repeatedly having conflicts between resource/interfaces.

The report displays the following information for each operator:

- name of each channel pair
- conflict value assigned

- number of times the channel pair was exercised

Task Timeline Chart

The task timeline chart is a two-dimensional representation of the execution of each task in the mission relative to a timeline. The horizontal axis displays the time. Tasks are represented by horizontal boxes that correspond to the time the task was executing. If a task executed multiple times, multiple boxes are drawn for that task. The task names are displayed with the boxes.

The original timeline is drawn with the time scale ranging from time 0 through mission completion time. IMPRINT allows you to re-scale the time (horizontal) axis in order to view specific time periods in more detail. To re-scale the axis, click on the “Time Scale” button.

If your mission contained more tasks than can fit on one page, you can page through the timeline.

Crewstation Workload Report

The Crewstation Workload Report allows you to save the workload data from the current run or view workload data from any previously saved run.

Save the current run file by typing in a name for the file (maximum of 8 characters) in the filename field. We recommend that you end your file name with .txt extension.

Look at a saved workload profile by entering the name of the file to be viewed and selecting the “View” button. IMPRINT will then display the tabular form of the workload information.

Maintenance Model Results

To create maintenance model reports, choose the “Maintenance Model Results...” option from the “Reports” menu. When you make this menu selection, you will be able to select the Scenario for which you want reports generated for and the specific reports themselves. Reports you can choose from correspond to Maintenance Summary, Daily Maintenance, Reliability and Availability, Maintenance Hit Matrix, Daily Reliability, Maintainability, Headcount Frequencies, Manhour Requirements, Combat Damage, and Logistical Wait Summary. One or more reports can be selected by clicking and highlighting on the appropriate report title. Clicking a second time on a highlighted report title will deselect that report. Finally, clicking on the Reports button will generate and display the selected reports.

You can also export the data from your reports to other file formats. IMPRINT uses a commercial tool called Crystal Reports to generate and display reports. When a report is displayed, you can choose to export the data to a file by clicking on the envelope icon in the tool bar. at the top of the report. You will then be able to select the output format you want.

Maintenance Summary Report

The maintenance summary report contains four data items that summarize the maintenance requirements that were generated during the simulation. This report includes the average corrective and preventive maintenance manhours that were simulated for each system. These are calculated by taking the total amount of manhours in each category, and dividing by the total number of systems in the scenario. Also included is the average maintenance manhours simulated per operational hour. This is calculated by dividing the sum of the preventive and corrective maintenance manhours by the total operating hours for all systems.

Daily Maintenance Report

This report contains the amount of maintenance manhours that were simulated at all organizational level types (e.g., ORG, DS, GS) for both maintenance types (e.g., preventive, corrective). This report has scroll bars to scroll up and down, as well as left and right.

The values in this report are totals across all systems.

Reliability and Availability Report

This report has two parts. The first part is the Reliability Summary. It includes the number of segments requested and accomplished during the simulation. The report also includes measures for the number of times systems were requested, and the number of times that those system requests were accomplished. If you had one segment and a maximum of two systems assigned to that segment, then that will be reported as "Number of times Systems Requested" = 2. If only one of the systems actually performed the segment (because the other system was either busy or in maintenance), then that will be reported as "Number of times System Requests Accomplished" = 1.

The second part of the screen includes an Availability Summary. The values are calculated as follows:

- Average inherent availability = ((scenario length in hours x # of systems) minus (total clock hours on corrective maintenance)) divided by (scenario length in hours x # of systems)
- Average achieved availability = ((scenario length in hours x # of systems) minus (total clock hours on corrective + preventive maintenance)) divided by (scenario length in hours x # of systems)

(Note that inherent & achieved availability consider the total number of days simulated in hours (e.g., 365 * 24), minus the number of clock hours spent in maintenance. Therefore, if 2 or more soldiers are working at the same time on the same system, there are counted just once. Similarly, if two maintenance tasks are being worked at the same time, it is only counted once.)

- Readiness = segments accomplished divided by segments requested

Maintenance Hit Matrix Report

This report is an exhaustive listing of the maintenance tasks that occurred during your simulation. The report scrolls up and down as well as to the left and right. The columns of the report are:

- Subsystem Name
- Component Name
- Task Name
- Maintenance Task Type (Preventive or Corrective)
- Organizational level type at which the maintenance action will be performed (e.g., ORG, DS, GS)
- First MOS that was assigned to perform the maintenance action
- Number of maintainers of the first MOS that must work together to perform the task
- Second MOS that was assigned to perform the maintenance action
- Number of maintainers of the second MOS that must work together to perform the task
- The number of times the task was triggered during the simulation
- Total maintenance manhours simulated on the maintenance action

This maintenance hit matrix includes maintenance tasks that never occurred. You will identify those actions by noting the zeros in the “Occurrences”, or number of occurrences, column. If many of your tasks have not occurred, it indicates that your simulation did not run long enough for the system to require these maintenance tasks (i.e., the mean operational units between failure (MOUBF) for the tasks is longer than the simulation time period). This probably indicates that you should lengthen the simulation run, and re-execute the model.

Since maintenance tasks are triggered by comparing their MOUBF to a standard exponential curve of accrued usage on each component in the system, there is some randomness associated with simulating when the maintenance task will occur. For this reason, we recommend that you execute the IMPRINT scenario with a variety of random number seeds to ensure that you have generated a representative set of results.

Daily Reliability Report

The daily reliability report provides a summary of the number of segments and segment requests generated by the simulation for each day of the scenario.

Maintainability Report

The simulated maintenance manhours per operational hour are included in this report. This is calculated by dividing the total manhours of maintenance performed on each subsystem by the total number of operational hours of the scenario. Also, the simulated manhours per hour are reported. This measure is calculated by dividing the total manhours of maintenance performed on each subsystem by the total length of the scenario (in hours).

Headcount Frequencies Report

This report contains the percentage of time that different numbers of people were busy for a specific MOS and organizational level type (e.g., ORG, DS, GS). This report is based on the entire length of the simulation, not just the times during the simulation that this MOS was busy or on duty.

This report provides a measure of MOS utilization. It illustrates the frequency with which different numbers of people in each MOS were used. The highest bin for which a > 0% utilization is shown will never exceed the shift manning levels you set for that MOS and that organizational level type. Additionally, if the highest bin shown has a relatively high frequency, as in the example of 20% of the time three people being used, then it is possible that you have constrained this MOS so tightly that it is reducing system availability.

We recommend that you perform the first IMPRINT maintenance model run with the shift manning levels unconstrained. This will result in a simulation that optimizes system availability from the perspective of manpower. Put another way, the simulation will assume that the manpower required to perform any maintenance action will be available. After running the IMPRINT maintenance model in the unconstrained mode, you should examine this Headcount Frequency report for guidance on how to best constrain your shift manning pools (i.e., to minimize the effect on system availability). We recommend that you focus on reducing manpower pools for MOS's that have low utilizations.

Manhour Requirements Report

This report has three columns. They are organizational level, MOS, and direct maintenance manhours. This report is useful for identifying the MOS's that are performing the most maintenance.

Combat Damage Report

This is a brief report that lists the number of combat hits that were simulated for all your systems throughout the entire length of the simulation run. This report also lists the number of simulated attritions, or kills. Finally, the repair time in total number of hours is included. These metrics are stochastically driven as a result of the combat parameters entered earlier in IMPRINT.

The combat parameters are mission-specific and include the probability of combat hit per hour, the probability of attrition or repair, and the time it takes to either replace a destroyed system or repair a damaged system.

Logistical Wait Summary

The Logistical Wait Summary Maintenance Report includes two measures. These are the amount of time systems spent waiting for spare parts and the amount of time systems spent waiting for maintainers. Each of these measures are reported by organizational level.

If the amount of time systems spent waiting for spare parts is excessive, you will want to either increase the probability that spares are available or decrease the amount of time required to procure a spare under the "spares" button in Define Equipment.

If the amount of time systems spent waiting for maintainers seems excessive, you will either want to increase the number of people in your manpower pools, or you should increase your shift lengths, or you could decrease the operational profile for your systems. Each of these options are available under the Define Equipment portion of IMPRINT.

Supply and Support Results

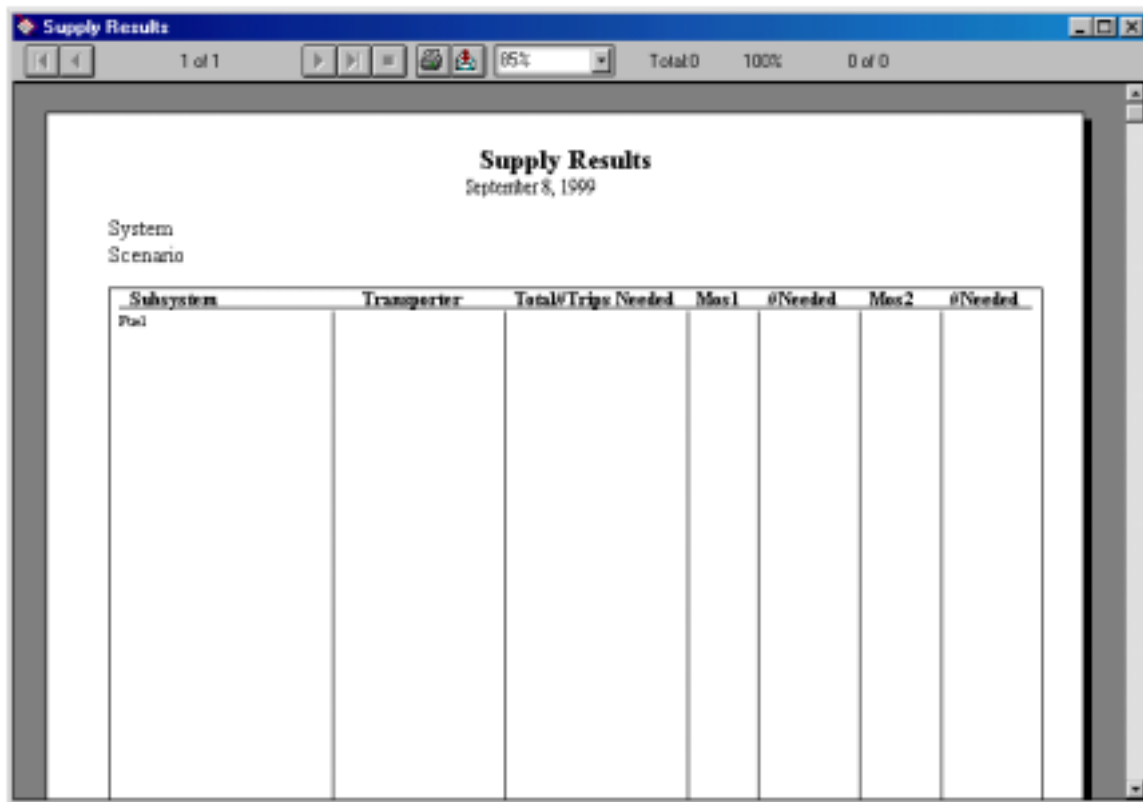


Figure 3-67. Supply and Support Report

To create Supply and Support reports, choose the "Supply and Support Results" option from the "Reports" menu. When you make this menu selection, you will be able to select the scenario for which you want reports generated.

You can also export the data from your reports to other file formats. IMPRINT uses a commercial tool called Crystal Reports to generate and display reports. When a report is displayed, you can choose to export the data to a file by clicking on the envelope icon in the tool bar at the top of the report. You will then be able to select the output format you want.

This report contains the fuel and ammunition requirements needed in order to support a

mission. These support requirements are based on the daily fuel and ammunition requirements for a particular scenario entered under Define Equipment and the capacity and manpower available per transporter entered under Define Supply. The columns of the report are:

- Subsystem name
- Transporter name
- Total number of trips needed
- First MOS that was assigned to transport the fuel
- Number of the transporters of the first MOS that must work together to perform the task
- Second MOS that was assigned to transport the fuel
- Number of the transporters of the second MOS that must work together to perform the task

Projection Model Results

Figure 3-68. Projection Report Criteria

To create projection model reports, choose the "Projection Model Results" option from the "Reports" menu. When you make this menu selection, you will be able to select setup parameters for several reports that can be generated from the results of the Projection Model. When you press the Report button, you will get the MOS Projected Inventory Report.

You can also export the data from your reports to other file formats. IMPRINT uses a commercial tool called Crystal Reports to generate and display reports. When a report is

displayed, you can choose to export the data to a file by clicking on the envelope icon in the tool bar. at the top of the report. You will then be able to select the output format you want.

Projected Inventory Report

The Projected Inventory Report is generated from the results of the Projection Model. This report tells you the number of people in each MOS by grade.

Education Check Box

Check one or more education level categories to be displayed for the selected MOS. To display the entire MOS, check all boxes.

Gender Check box

Check one or more gender categories to be displayed for the selected MOS. To display the entire MOS, check all boxes.

Mental Category Checkbox

This option allows you to set a minimum "mental category" for a Military Occupational Specialty (MOS) and then see how performance would be affected. Mental category (now called "Test Score Category") refers to the score obtained on the Armed Forces Qualification Test (AFQT), which is derived from the ASVAB.

The different Test Score Categories are:

Test Score Category	AFQT Score
I	93-99
II	65-92
IIIA	50-64
IIIB	31-49
IV	10-30

Personnel Characteristics Reports

Figure 3-69. Personnel Characteristics Report Criteria

Use this screen to create a report on the numbers of soldiers in each MOS that have specific personnel characteristic levels. Use the check boxes on the screen to set up the parameters of the report. Use the buttons to select the characteristic for which you want to view a report.

Mental Category Checkbox

This option allows you to set a minimum "mental category" for a Military Occupational Specialty (MOS) and then see how performance would be affected. Mental category (now called "Test Score Category") refers to the score obtained on the Armed Forces Qualification Test (AFQT), which is derived from the ASVAB.

The different Test Score Categories are:

Test Score Category	AFQT Score
I	93-99
II	65-92
IIIA	50-64
IIIB	31-49
IV	10-30

Gender Check box

Check one or more gender categories to be displayed for the selected MOS. To display the entire MOS, check all boxes.

Education Check Box

Check one or more education level categories to be displayed for the selected MOS. To display the entire MOS, check all boxes.

Reading Grade Level Button

If you click on this button, a report that displays the numbers of people in each Reading Grade Level Category in the subpopulation defined by your Gender, Mental Category, and Education check box choices.

Weight Lift Button

If you click on this button, a report that displays the numbers of people in each Weight Lift Category in the subpopulation defined by your Gender, Mental Category, and Education check box choices.

PULHES (Eyes) Button

If you click on this button, a report that displays the numbers of people in PULHES Eyes Category in the subpopulation defined by your Gender, Mental Category, and Education check box choices.

ASVAB Button

If you click on this button, a report that displays the numbers of people in each ASVAB cutoff score in the subpopulation defined by your Gender, Mental Category, and Education check box choices.

Mental Category Report

Figure 3-70. Mental Category Report

Use this screen to create a report that lists of the numbers of soldiers in each MOS that have specific mental category levels. Use the check boxes on the screen to define the subpopulations that you want to include in the report.

The different Test Score Categories are:

Test Score Category	AFQT Score
I	93-99
II	65-92
IIIA	50-64
IIIB	31-49
IV	10-30

Gender Check box

Check one or more gender categories to be displayed for the selected MOS. To display the entire MOS, check all boxes.

Education Check Box

Check one or more education level categories to be displayed for the selected MOS. To display the entire MOS, check all boxes.

Education Report

Figure 3-71. Education Report Criteria

Use this screen to create a report that lists of the numbers of soldiers in each MOS that have specific education levels. Use the check boxes on the screen to define the subpopulations that you want to include in the report.

Mental Category Checkbox

This option allows you to set a minimum "mental category" for a Military Occupational Specialty (MOS) and then see how performance would be affected. Mental category (now called "Test Score Category") refers to the score obtained on the Armed Forces Qualification Test (AFQT), which is derived from the ASVAB.

The different Test Score Categories are:

Test Score Category	AFQT Score
I	93-99
II	65-92
IIIA	50-64
IIIB	31-49
IV	10-30

Gender Check box

Check one or more gender categories to be displayed for the selected MOS. To display the entire MOS, check all boxes.

Gender Report

Figure 3-72. Gender Report Criteria

Use this screen to create a report that lists of the numbers of soldiers in each MOS by gender. Use the check boxes on the screen to define the subpopulations that you want to include in the report.

Mental Category Checkbox

This option allows you to set a minimum "mental category" for a Military Occupational Specialty (MOS) and then see how performance would be affected. Mental category (now called "Test Score Category") refers to the score obtained on the Armed Forces Qualification Test (AFQT), which is derived from the ASVAB.

The different Test Score Categories are:

Test Score Category	AFQT Score
I	93-99
II	65-92
IIIA	50-64
IIIB	31-49
IV	10-30

Education Check Box

Check one or more education level categories to be displayed for the selected MOS. To display the entire MOS, check all boxes.

Force Reports

Force Structure Report

The Force Structure Report lists all the units that will be getting the new weapon system. It includes the parent unit, the unit type and size, and the number of systems that will be fielded in each unit by year.

The column headings are as follows:

- Org Level - Parent unit of the unit type and size listed (e.g., Division or CORPS)
- Unit Type - Type of unit, such as mechanized infantry or air defense
- Unit Size - size of unit, such as company or battalion
- Units - The number of similar units (as described in the previous column headings) existing in the Army's current Force Structure in which the new system will be fielded
- Systems per Unit - Number of new systems that will be fielded in each unit
- Year - The year in which the new systems will be fielded in the unit(s)

Total Manpower Requirements by Year Report

This report lists the total number of operators, maintainers, and support personnel required to support the new system. The column headings are:

- Duty Position - Operator, maintainer, or support duty position.
- Operators - Number of operators required.
- Maintainers - Number of maintainers required.
- Support - Number of support personnel required.
- Year - Year in which manpower requirement occurs.

Total Manpower Requirements by Unit Report

This report lists manpower requirements for each type of unit in the Force Structure that will be getting the new system. The column headings are:

- Org Level - The parent organization for the unit type
- Unit Type - Type of unit, such as mechanized infantry or air defense
- Unit Size - size of unit, such as company or battalion
- Systems per Unit - Number of new systems that will be fielded in each unit
- OPTEMPO Per Day - The average number of hours each system operates in a 24 hour period
- MOS - The MOS or designation of operator, maintainer, or support personnel required to support the new systems in the units listed

Manpower Estimate Report (MER)

The Manpower Estimate Report is formatted in accordance with DoDI 500.2 which specifies how manpower requirements for a new system are to be documented. The major categories of manpower are operators, maintainers, support, and trainers. These categories are further broken out by military, civilian and contractor. The cumulative requirements, authorizations, and differences are given for each year until the new system is completely fielded and steady state is reached.

IMPRINT does not provide values for all of the needed categories. Only military operators and maintainers are included.

Adjust Menu

Workload Overload Reassignment

Manual Task Reallocation

CrewMember1

Time: 00:00:00.00 minutes < Previous Next >

Function	Task	V	A	C	P
UnNamed 1	UnNamed 1	7.00000	0.00000	0.00000	0.00000
UnNamed 2	UnNamed 1	7.00000	0.00000	0.00000	0.00000

Reallocate

Overall Expression: 0.000000

Violated Definition: (V > 5) | (N > 1)

OK Cancel Help

Figure 3-73. Manual Task Reallocation

You can use the Workload Overload Reassignment option under the Adjust menu item to reassign tasks that were performed during points of VACP workload overload. For each point of overload, IMPRINT provides you a list of the tasks that were being performed in parallel by an operator during a point of workload overload. The VACP scores of each task are also included. At the bottom of the interface, IMPRINT tells you what the overall expression evaluated to at this time, and which workload overload definitions were violated.

To reassign one of the tasks, you must have first identified secondary operators for the selected tasks. If you have not identified secondary operators, IMPRINT will remind you of this. You can either attempt to reallocate a different task, or you can return to the define mission portion of IMPRINT and assign secondary operators. Then, you will have to re-execute your mission before adjusting for overload.

After you have moved through all the points of overload (using the next and previous buttons at the top of this screen), you must re-execute your mission to ensure that overloads have been alleviated. Additionally, it will be important that you change the random number seed and run it several more times to provide your tasks and opportunity to sample from the distribution of times, accuracies and branching logic. A different random number seed may actually trigger different overload points.

Chapter 4 - Overview of the IMPRINT Operations Model

The purpose of this chapter is to describe the process that is followed when you execute an IMPRINT Operations Model.

To begin execution of the model click on the Run Model button. When the model begins, the first thing that happens is that the data in your analysis database will be used to compile a file (named imprint.mod) that is formatted so that Micro Saint can execute it. Then, Micro Saint is started and the execution will begin to process the data file. If you have checked the Animation option, you will see the Micro Saint task network display.

The Micro Saint engine begins by attempting to process the very first task in your task network that follows the 0 (Start) function. If there is a function following the 0 function, then it will begin with the first task of that function. All the parameters associated with a task are then processed in order.

Step 1 - Evaluate the Release Condition - The first thing that it does when it starts running is make sure that the release condition evaluates to non-zero (i.e., is ok to start). In a VACP model, you can not directly edit a Release Condition. They are automatically generated based on your rejoin data. In an Advanced Mission, you can enter Release Conditions directly. Also, in an Advanced Mission, a portion of the Release Condition is automatically generated. It's purpose is to determine whether the beginning of this task would put the assigned operator into overload. If it will put the operator into overload, then the appropriate workload management strategy is implemented (e.g., the task is reassigned to a different operator, is not started, is dumped, or the performance is penalized). If the Release Condition evaluates to non-zero and the overload information calculates acceptably, then Micro Saint proceeds to the second parameter.

Step 2 - Calculate a task performance time - In this step, Micro Saint pulls a random number out of the generator and uses that number, along with the Mean Time, the Standard Deviation, and the Distribution, to calculate a precise task time for this occurrence of the task. It will add this time to the current simulation time, and use that to schedule the completion of this task. If task performance time is being penalized (either because of Personnel Characteristics, Training Frequencies, and Stressor (PTS) settings or because of overload or failure consequence penalties), then this adjustment is included.

Step 3 - Next, Micro Saint executes the task's Beginning Effect. - In a VACP model, you can not enter a Beginning Effect. Rather, it is generated automatically, and performs calculations that assign the task to the operator you have chosen, and increments the workload values associated with the task. If you are executing an Advanced Mission, then any expressions you have entered are also executed.

Step 4 - Begin the task - Then the task will be highlighted on the Micro Saint Animated

task network, and it will become active.

Step 5 - Task interruptions - In an Advanced Model, a task can be interrupted because a higher priority task needs to begin. In this event, Micro Saint records the amount of time that the task has already been executing. If the task is going to be resumed, then Micro Saint adjusts the performance time to account for the fact that some time has already been expended. If the task is going to be restarted, then Micro Saint recalculates a new performance time that will be used when the task is restarted.

Step 6 - Task completion - Once the appropriate amount of time has passed in the simulation, the task's scheduled time for completion will occur. When this happens, the first thing that Micro Saint does is process the task's Ending Effect. In a VACP mission, the Ending Effect is generated automatically. It adjusts the current workload values and makes the operator available. In an Advanced Mission, these automatic calculations are done, and then any Ending Effect that you have entered is performed.

Step 7 - Evaluate Accuracy - Next, Micro Saint uses the random number generator and compares the result against the task's probability of success to determine whether the task succeeded or failed on this particular occurrence. If you selected Adjustments, and have adjusted the task accuracy for PTS effects, the new "adjusted" task accuracy will be used. Otherwise the task accuracy that you entered on the Task Information dialog will be used. If the task failed, then the failure consequences are evaluated. If the task succeeded, then we skip the next step.

Step 8 - Evaluate Failure Consequences - If a task failed to meet its accuracy standard, then Micro Saint draws another random number to determine which Consequence of Failure should be implemented. The random number is compared to the distribution of Failure Consequences you entered. The appropriate consequence is then implemented. If the failure consequences changes the following task, then the next step is skipped, and that task is started, using the same procedure described in the previous steps. If the failed task has a Failure Consequence where another task follows it, and that task is the same task (i.e., you repeat the task in the event of failure), then each occurrence is counted separately.

Step 9 - Select following tasks - If the task has completed normally, then the decision type is evaluated to determine which following tasks could be started. If there is more than one following task (i.e., multiple decision), then each task is started in the order in which it is listed on your IMPRINT decision branching dialog. Each task is started and processed using the same procedure described in the previous steps.

This procedure continues until no more tasks are executing. The mission, function and task performance reports include records of the number of times each task occurred, as well as the minimum, maximum, mean and standard deviation of the performance time. Also, the task performance report includes a record of the percentage of times that the task failed to be performed accurately. The function performance time is calculated by

subtracting the time at which the first task in the function began from the time that the final task in the function completed.. The mission performance time is calculated by recording the time that the final task in the model completed. Mission performance accuracy is calculated by recording the total number of times that the mission was executed, and comparing it to the number of times that the mission was aborted because a task with that particular failure consequence failed.

The process we have described is a standard process for discrete event simulation tools. For further information, we recommend that you refer to a discrete event simulation textbook.

Chapter 5 - Overview of the IMPRINT Maintenance Model

The purpose of this chapter is to describe how the maintenance analysis works. We recognize that this is a very technical topic, however, we have attempted to simplify it as much as possible. We expect that the reader will have some understanding of discrete event simulation modeling, however we do not expect the user to understand Micro Saint syntax. Additionally, we expect that the user will be very familiar with the terms used on the IMPRINT screens for the Define Equipment portion of the tool.

So how does the maintenance model really work?

The maintenance model is composed of three pieces.

1. Metbase.mod is the base Micro Saint model. It is a “canned” model that represents the way that systems and components will flow through maintenance. It contains the task network for the maintenance model. It is static, in that user entries do not have an effect on the content of this file. The metbase.mod file will not run by itself. It is an ASCII text file and has a very specific format. It should not be edited by a user. If this file is deleted, IMPRINT can not execute the maintenance model and will return a “missing metbase.mod file” error.
2. Metbase.evt is the file of user data from the IMPRINT database. It is generated when the user pushes the “Run” button from the Execute Maintenance Model interface. This file is generated in the form of Micro Saint Scenario Events. It will not execute in Micro Saint by itself. It is an ASCII text file and has a very specific format. It should not be edited by a user.
3. Met.mod is generated by inserting the metbase.evt file into the middle of the metbase.mod file. IMPRINT performs this operation immediately after it generates the metbase.evt model, and immediately before it tells Micro Saint to begin executing the new met.mod model. This ASCII text file is in a very specific format, and should not be edited by a user. The Met.mod file defines the data that drives a discrete event task network simulation model.

How is Micro Saint started?

A specially developed run-time version of Micro Saint is started using a command line argument from IMPRINT. This will tell Micro Saint to run in the background, and will also tell it to execute the met.mod data file. Finally, it will turn on the data collection capabilities.

How does the Analysis Flow?

Figures 1-3, below, are the task networks that reside in metbase.mod, and are then

incorporated into the met.mod that is executed by Micro Saint.

While the logic involved in making the model run is quite complex, we will provide a basic overview here.

The maintenance analysis model can be thought of as having three separate, but interrelated parts. The first part, shown in Figure 1, controls the flow of systems into mission segments. In this part of the model, the entities flowing through the network represent individual systems (e.g., tanks, helicopters). This part of the model controls the accrual of usage to each individual component of each system (based on the distance traveled, rounds fired, and time operated). It also predicts any combat damage. Before sending a system out to perform a mission segment, IMPRINT “looks ahead” to see whether the mission segment will be aborted due to a failure of a critical component. If it determines that the mission segment will be aborted, it is careful to accrue only the completed proportion of usage to all components in that particular system. When the system returns from a mission segment, each non-abort component in each system is checked to determine whether the accrued usage is greater than the failure clock. It is important to note the amount of fidelity that is represented in the model. IMPRINT tracks separate failure clocks for each maintenance action (i.e., combination of repair task and component) on each system.

For any system that now has any components that are in need of maintenance, the parent system is removed from the “systems available” pool, and the maintenance actions are sent to the second part of the model, depicted in Figure 2.

There are also some book-keeping tasks in Part 1. These are used to maintain statistics by the day and by the shift.

Network 0 MET

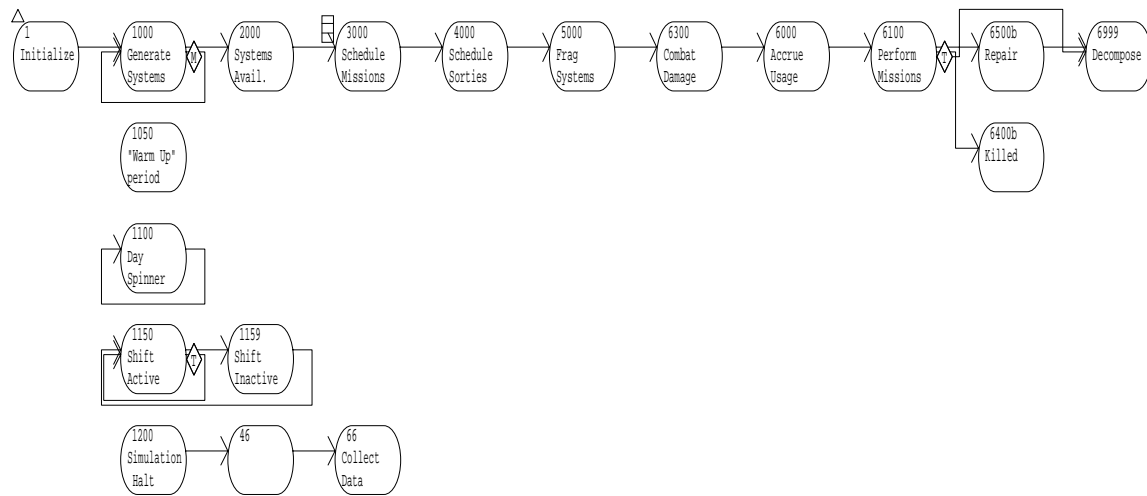


Figure 5-1. Part 1 of Met.Mod

In Part 2 of the model, the maintenance actions are performed. In this portion of the model, the entities flowing through the network represent maintenance actions. Maintenance actions are queued up in front of their respective organizational levels. If the maintenance action is “remove and replace” and the organizational level is Unit Level (ORG), then the spare parts parameters for the parent subsystem are examined to see if the spare is actually needed, and if so, whether it is available. If it is not available, the system repair is delayed for the appropriate time.

All organizational maintenance for an individual system must be completed before direct support maintenance begins for that system. Similarly, all direct support must be completed for that system before any general support maintenance can begin. The queues associated with each organizational level are sorted by a fairly complex strategy.

The total predicted maintenance time for each system is estimated by summing the mean times to repair for all the tasks for a specific system. The maintenance actions are then placed in an initial order that gives priority to the system with the shortest estimated total maintenance time. Then, the manpower requirements of the maintenance actions in the queues are compared to the available manpower pool (by Military Occupational Specialty (MOS), skill level) for each organizational level. The maximum number of tasks that can be released are then sent into the tasks where maintenance is performed. This strategy is careful to keep maintenance actions from being “holed.” This means that if a maintenance action takes fewer maintainers than one that is above it in the queue, and insufficient maintainers are available to process the high priority action, the lower priority task will be released.

One final issue associated with this process is that all maintenance actions that are not complete at the end of a shift will be interrupted until enough maintainers are available on the next manned shift in order to complete the action. Maintenance actions that are interrupted are always given a higher priority than actions that have not yet begun.

When all maintenance actions for a particular system are complete, the system is “reconstituted” and sent back to the system available pool. It is then available to be assigned to any upcoming mission segments.

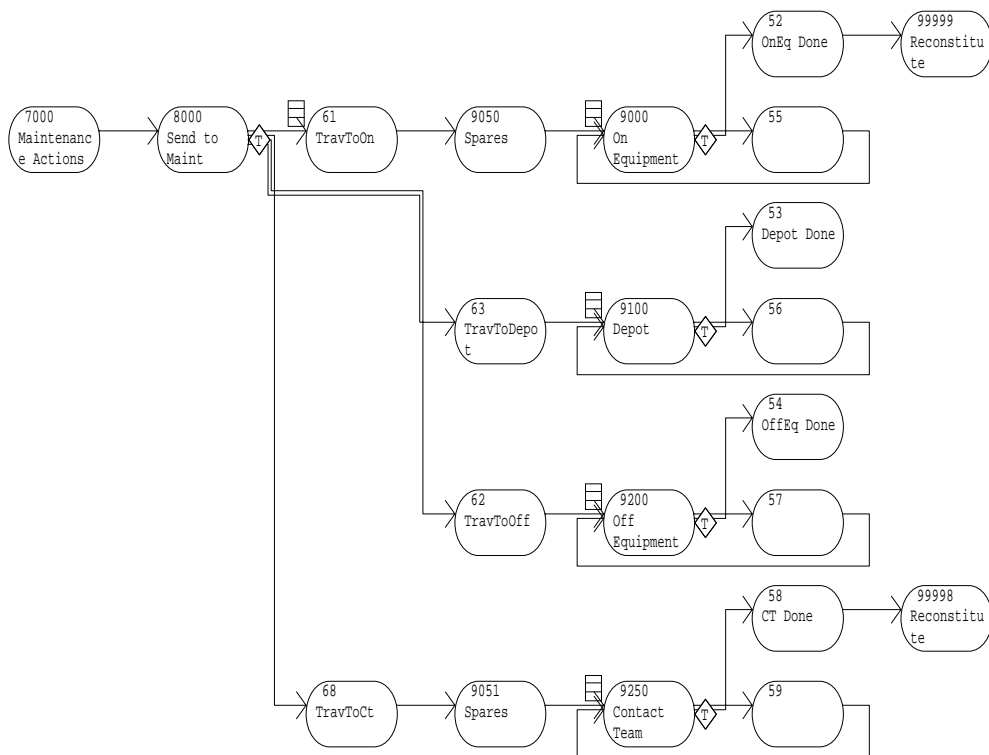


Figure 5-2. Part 2 of Met.Mod

Part 3 of the model runs in parallel to the first two parts. In this part, the entities flowing through the network represent mission segments. The purpose of this portion of the model is to schedule mission segments and to determine whether they should be released or canceled. Mission segments are released if there are enough systems in the available pool to meet the minimum number required at the mission start time. If the mission

segment is not filled to its minimum at that time, the model continues to try to gather enough available systems by the mission cancellation time. If not enough systems are available at cancellation time, the mission is canceled and all systems are returned to the available pool.

The scheduler uses the mission segment priority to determine which mission segment systems will be assigned to if more than one segment is scheduled to leave at the same time. If this happens, then the model will attempt to fill each mission segment's minimum, before filling the mission segment to the maximum.

Network 0 MET

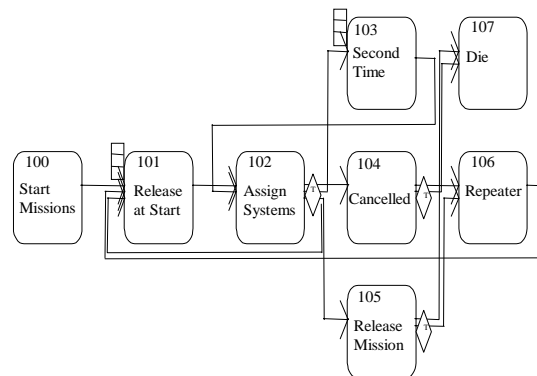


Figure 5-3. Part 3 of Met.Mod

How are the results of the model collected?

The results of the model run are gathered in two ways. There are some customized functions built into this version of the Micro Saint run time engine that collect values of variables that are calculated within the model. Also, several Micro Saint snapshots have been defined that are used to collect results. All the results are stored in your IMPRINT directory in files with a “.res” extension. These are ASCII text files that can be opened by other applications (e.g., Microsoft Excel). We do not recommend that you use this method of examining your results. IMPRINT does take the results from your Micro Saint .res files and stores them in your IMPRINT database. These results are then accessible through the Maintenance Models option on the IMPRINT Reports menu pull-down.

Chapter 6 - Errors

There are several different classes of errors. These include errors that are from IMPRINT, from the IMPRINT databases, from the Crystal Reports report generator, and from the Micro Saint simulation engine. Errors can mean that you have a specific problem with your analysis, that there is a problem with your computer system (e.g., insufficient memory, insufficient storage capacity, inconsistent Dynamic Linked Library (DLL) setups). In the table below, we describe the text of the error, the type, and how to respond to the error. If you encounter an error that is not in this table, and you do not know how to respond, please contact IMPRINT technical support.

Text	Type	What to do
A semi-colon is required at the end of beginning effects	IMPRINT error message	You have entered a task beginning effect on the Effects tab of the Task Information screen. All expressions must be terminated with semi colons. For more information regarding the correct syntax for the expressions, please refer to the IMPRINT User's Guide.
A semi-colon is required at the end of ending effects	IMPRINT error message	You have entered a task ending effect on the Effects tab of the Task Information screen. All expressions must be terminated with semi colons. For more information regarding the correct syntax for the expressions, please refer to the IMPRINT User's Guide.
A semi-colon is required at the end of release conditions	IMPRINT error message	You have entered a task release condition on the Effects tab of the Task Information screen. All expressions must be terminated with semi colons. For more information regarding the correct syntax for the expressions, please refer to the IMPRINT User's Guide.
All task operators must have a resource/interface channel assigned before the model can run. Operator XXX does not for task XXX.	IMPRINT error message	You have attempted to execute an Advanced Workload model, but you have not assigned channels to tasks. You must return to the Options menu, select the Workload and Crewstation Parameters item, and enter these data.
Error Reading Data	Database error message	IMPRINT was not able to read your data. This might be because you opened this

		analysis with a more recent version of IMPRINT than you are now using. Your analysis database could also be corrupted. We recommend that you contact technical support.
Error Saving Analysis	IMPRINT error message	IMPRINT was not able to save your analysis. This is probably because your disk is full, but could also be because something in your analysis is corrupted. If you are unable to save after making sure you have at least 10 MB available on your disk, please contact technical support BEFORE you turn your PC off.
Error Writing Data	Database error message	IMPRINT was not able to write your data. This might be because you have duplicate records in your data. There is nothing you can do to fix this, and we recommend that you contact technical support immediately.
Every task must have at least one operator assigned to it. This task does not: XXX	IMPRINT error message	You have attempted to execute an Advanced Workload Model, but all the tasks have not been assigned to operators. You must return to the Oper Assgn tab on the Task Information screen and assign an operator to each task.
Force data are not available for this system	IMPRINT information message	You attempt to Define the Force Structure of your system, but you have not defined a maintenance scenario. You must Define Equipment and add a scenario before you can Define the Force Structure.
General Protection Fault (GPF)	IMPRINT error message.	This is a critical and catastrophic failure. It is typically caused by insufficient Random Access Memory (RAM). You will have to reboot your system to recover. You should then make sure that you have at least 32 MB of RAM available on your system. If you have lost any data, refer to the "Autosave" feature in order to recover. If you do not have sufficient RAM, you may have to upgrade your system.
In order to adjust for Workload Overload, you must first run the operations model from the Execute menu.	IMPRINT information message	You have accessed the Workload Overload item on the Adjust menu before executing the operations model that you have open. You must first execute this model by choosing the Operations Model item on the Execute menu.

In order to copy functions, you must first open a mission in Define System Mission	IMPRINT information message	You are attempting to duplicate functions from one mission to another without having opened a mission into which the functions would be copied. Click on the OK button, then return to the mission tab and select a mission.
In order to generate a report, you must first run the projection model.	IMPRINT information message	You have attempted to display a report that does not contain data. You must go to Define Soldiers and run the projection model before you can display this report.
In order to print this report, you must first run the Maintenance Model from Execute for the scenario you selected.	IMPRINT information message	You attempted to display a Force Report, but you have not executed the maintenance scenario model that you selected. Return to the Execute menu and run the maintenance model.
Invalid Record Format; Import Aborted	IMPRINT error message	You attempted to import or append data to your analysis, and the import file you selected is in an improper format. Click on the OK button, then select a file that is of the correct format. For information on the proper format for Append task files, please refer to the appropriate topic in the IMPRINT User's Guide.
Model Generation Failed	IMPRINT error message	IMPRINT attempted to generate an Advanced Mission model but was unable to complete this operation. Most likely, this is because you are missing some of the necessary data files from your directory. Go to your IMPRINT directory and make sure that basevar.dat, opervar.dat, taskvar.dat, and funcinfo.dat are present. If they are not, contact technical support for replacement files. If these files are present, make sure that your hard disk has sufficient space available. You should have at least 10 MB free.
Negative mean time in job XXX	Micro Saint error message	This error indicates that the model generated by IMPRINT that Micro Saint is attempting to execute is corrupted. Please contact technical support.
No Operator or Maintainer MOS's exist	IMPRINT information message	You have attempted to access the PTS option on the Options menu, but you have not defined any soldiers for your system. You can not apply personnel

		characteristics, training frequencies, or stressor adjustments until you have defined soldiers. You must return to the Soldiers option on the Define menu and complete this operation.
No tasks found for MOS. Taxons must first be assigned.	IMPRINT information message	You have attempted to access the PTS option on the Options menu, but you have not assigned Taxons to your tasks. You can not apply personnel characteristics, training frequencies, or stressor adjustments until you have assigned your taxons to your tasks. You must return to the Task Information dialog, choose the Taxons tab, and assign values.
Not a unique name	IMPRINT error message	You have attempted to duplicate a data item without entering a unique name. Click on the OK button, then return to the duplicate command and enter a unique name.
ODBC access resulted in error. Database access error.	Database error message	IMPRINT was not able to open your databases. This could be because some of your .db files have been moved or deleted. You should have IMPRINT.db, cleandb.db, director.db, and template.db in your IMPRINT directory. Click on OK. Make sure these files are where they should be. If they are not, you may need to reinstall IMPRINT. We suggest you contact technical support.
Save current analysis before closing it? If you choose not to save, all changes made in this session will be lost	IMPRINT information message	Click on the Yes button to save, the No button to cancel changes and exit, and the Cancel button to cancel the current command and return to IMPRINT.
Save your diagrams with their task and function information?	IMPRINT information message	You are exiting from the network diagram and you have made some changes. IMPRINT is asking if you want to save the new network layout. If you click on Yes, the information will be saved. If you click on No, the changes will be canceled. If you click on Cancel, you will be returned to the network drawing. NOTE: THIS DOES NOT REPLACE THE NEED FOR YOU TO PERFORM A SAVE

		COMMAND ON THE FILE MENU. We recommend that you use the save command on the file menu often.
Task can never be released	Micro Saint error	This error was caused by a problem with either your rejoin tasks (if you have a VACP mission) or with your Release Conditions (if you are executing an Advanced Mission). If you have a VACP mission, return to the network diagram and study each of your multiple decisions to make sure that the rejoin task is correct. For more information, refer to the IMPRINT User's Manual. If you have an Advanced Mission, a task can not released until its Release Condition evaluates to a non-zero value. For more information on writing Release Condition expressions, please refer to the IMPRINT User's Manual.
The system has no scenarios so there is nothing to run	IMPRINT information message	You have attempted to Execute a maintenance model, but you have not entered any maintenance scenarios. You must return to Define Equipment and enter a scenario before you can execute the model.
The total task accuracy probability = xx. It must = 100.	IMPRINT error message	All of the percentages for the failure consequences on the Task Information tab must sum to 100 before you can save your results or leave the tab. Click on OK and then correct the values so that they sum to 100.
The Total Weight = x. It must = 1.0 or 0.0.	IMPRINT error message.	The weightings attached to the taxon categories on the Taxon tab of the Task Information screen must sum to either 1.0 or 0.0 before you can save your results or leave the tab. Click on OK and then correct the values so that they sum to 1.0 or 0.0.
There are no secondary crew members for any overloaded tasks	IMPRINT information message	You are attempting to reallocate tasks under the Adjust menu because you have points of overload in your mission. Unfortunately, you did not identify any secondary operators for the tasks that are contributing to overload, so there is no one to whom IMPRINT can reassign any of the

		troublesome tasks. You must return to the Crew Assgn tab of the Task Information dialog to identify secondary operators. You may have to add them to your Crew first (through the Crew button on the Mission Information screen) if you only have one operator in your analysis.
This analysis name and version already exists	IMPRINT error message	Click on OK and then enter a different analysis name or analysis version.
This file cannot be found. Make sure that you have specified the correct path and filename	IMPRINT error message	You have attempted to import a file that is not in the directory that you have entered. Click on the OK button and then use the browse capability to find the file you need.
This file type does not match the format you chose on the previous dialog box	IMPRINT error message	You are attempting to import data from LSA into IMPRINT. The format of the file you have selected is not what IMPRINT expects for the LSA version you have selected. If you are certain that the format is correct, review the IMPRINT User's Manual to make sure that the font and file layout are acceptable. If you still can not resolve the problem, contact technical support.
This option maps workload scales to task taxons for operator and maintainer tasks. Do you want to continue?	IMPRINT information message	You have chosen to map workloads to taxons. This will overwrite any existing taxon data with new values. This operation is not reversible. If you want to continue, click on Yes. If not, click on No.
This version of IMPRINT requires ALL functions at the top level and ALL tasks below them to generate a correct model	IMPRINT information message	This message is a reminder that Advanced Workload missions are limited to two levels in the task network. The top level must be composed of just functions, and the second level can only have tasks, in order for the model to run correctly. VACP missions can have tasks and functions mixed on any level and are not restricted to only two levels. Click on the OK button, and make sure that your mission layout is consistent with this requirement.
Time format HH:MM:SS.dd	IMPRINT error message	You have entered a time value in an improper format. The correct format is

expected		HH:MM:SS.dd. All the digits must be numerical. Click on the OK button and correct the error.
Unable to open source file	IMPRINT error message	IMPRINT was not able to open a file you selected. This is either because the path you chose is incorrect, or because the file is corrupted. If you are sure the path is correct, attempt to open another analysis. If you succeed at opening another analysis, your selected file is not properly formatted. If you cannot open another analysis, check to see whether there is sufficient room on your hard disk. You should have at least 10 MB available. If you still can not open the file, contact technical support.
You have chosen to perform an advanced workload analysis. In this version of IMPRINT, the task time and accuracy data can not be adjusted to account for personnel characteristics, stressors, or training. If you want IMPRINT to automatically adjust the task performance data for these variables, you should choose the basic VACP workload method.	IMPRINT information message.	You can not apply the PTS moderators to an Advanced Mission. This message is just reminding you of that fact. If you want to apply the PTS moderators, return to the Mission Information dialog and change the workload radio button to VACP.
You have no analyses to open	IMPRINT information message	You have attempted to open an analyses, but you do not have any existing analyses stored. Click on the OK button, then use New to begin working on a new analysis.
You must choose Advanced workload from the Mission Information screen to access this tab	IMPRINT error message	Some of the data items attached to tasks are only available if you are working on an Advanced Workload mission. Click on OK. Then, either pick another tab, or return to the Mission Information dialog and set the workload radio button to Advanced.

You must choose VACP Workload Analysis from the Define Mission/Mission Information screen.	IMPRINT error message	You have selected an option that is only appropriate for a VACP mission, but you have opened a mission that is identified as an Advanced Workload mission. Click on OK, then return to the Define Mission, Mission Information dialog and change the setting of the workload radio button.
You must choose VACP workload from the Mission Information screen to access this tab.	IMPRINT error message	You have attempted to access the Workload tab on the task information screen. You can only do this if you have opened a VACP mission. You must return to the Mission Information dialog and change the workload radio button to access this tab. Click OK to continue.
You must first choose a mission from Define Mission	IMPRINT information message	You attempted to perform an operation that applies to an IMPRINT operational mission, but you have not opened a mission yet. Click on the OK button, then go to Define Mission and open a mission.

Chapter 7 - Glossary

Analysis Description	This is a brief description of the analysis. The Analysis Description is optional.
Analysis Name	The Analysis Name can be 20 characters long and can include spaces and symbols. This information must be entered.
Analysis Version	The Analysis Version can be 20 characters long and can include spaces and symbols. This information must be entered.
Crew Ratio	Crew Ratio is the average number of crews available for each new system in the unit. In some cases where systems are required to operate continuously there may be multiple crews for each system.
Function Criterion	The Function Criterion is a percentage that determines how often the function must meet its Function Time Standard to be considered a success. Enter a value between 0 and 100, inclusive.
Function Name	The Function Name is a brief text label that you will use to uniquely identify each function in your system's mission. The function name is limited to 33 characters. All printable text characters are allowed, including spaces
Function Time Standard	The Time Standard is the slowest performance time that can be tolerated and have the function still be considered a success. When IMPRINT executes your mission model, the performance time that is predicted by the aggregation of all tasks in this function will be compared to this standard to ensure that your design can meet the function level time standard. The format for this entry (as with all other time values) is hh:mm:ss.00. So to enter a time standard of 30 minutes, 15 seconds enter 00:30:15.00. Notice that you can enter hundredths of a second after the decimal point.
Maximum Number of Systems	This value is the maximum number of systems that would be assigned to your segment if available.
Mean Time Expression	The Mean Time represents the average number of seconds required to execute a task. You can either enter a mean time value (00:00:30) or you can enter an expression(if clock<=30 then 10 else 15;). Each expression is delimited by semicolons. In building the expressions, you can use any of the algebraic or logical operators, including the following: (&, , >, <, :=, ==, +, -, *, and /) and you can use if-then-else statements. The assignment operator is :=. The equivalence operator is ==.
Minimum Number of Systems	This value is the minimum number of systems that must be ready to begin the segment prior to the cancellation time in order to prevent all departure groups from being canceled.
Mission Accuracy Criterion	The Mission Accuracy Criterion is a percentage that determines how often the mission must complete without abort to be considered a success. Aborts are caused when a task fails and the consequence of failure is mission abort. Values can range from 0 to 100.

Mission Criterion	The Mission Criterion is the percentage that represents how often the mission must meet both its time and accuracy standards at the same time. Values can range from 0 to 100.
Mission Description	Clicking this button displays a list of the crew members for the mission selected. The Mission Description is a fairly long text field that you can use to describe the mission you intend to model. The description is limited to 255 characters. All printable text characters are allowed.
Mission Name	The Mission Name is a brief text label that you will use to uniquely identify your system's mission. The mission name is limited to 60 characters. All printable text characters are allowed, including spaces.
Mission Time Criterion	The Mission Time Criterion is a percentage that determines how often the mission must meet its <u>Mission Time Standard</u> to be considered a success. Values can range from 0 to 100.
Mission Time Standard	The Time Standard is the slowest performance time that can be tolerated and have the mission still be considered a success. When IMPRINT executes your mission model, the performance time that is predicted by aggregating your individual tasks will be compared to this standard to ensure that your design can meet the mission level time standard. The format for this entry (as with all other time values) is hh:mm:ss.00. So, to enter a time standard of 30 minutes, 15 seconds enter 00:30:15.00. Notice that you can enter hundredths of a second after the decimal point.
MMH/System	Annual MMHs/system (ORG, DS, & GS levels) are the total number of annual maintenance manhours (by maintenance level) required to maintain one new system in that unit.
New Systems	This is the number of new systems that will be fielded in the unit.
Number of Days to Simulate	This is the number of days of operations that the IMPRINT maintenance model will simulate. If you define mission segments for more days than are entered here, the model will not execute any segments that go beyond this value. This value defaults to 10.
Number of Ongoing Tasks	This button lets you include the number of ongoing tasks in your expression to calculate overall workload. This value is shown as an "N" in your equation.
Number of Runs	If you would like to run a model more than one consecutive time, you can enter that number in this field. If you have a relatively short scenario (in days), you may want to run the model several times in order to be confident that the data you get from all of the runs is representative. One short run may, by chance, produce data that are not very typical. Running a model for a long period of time (e.g., 90 days) will also improve the probability that the results are typical. IMPRINT will automatically begin each run with a new random number seed. This value defaults to 1.
Number Per Departure Group	This value controls the number of systems per group (sometimes referred to as a "frag") that are sent out on this segment.
OP Tempo	Annual OP Tempo is the usage per year that the new system is expected to accrue in the type and size unit listed.

Overall Workload Expression	This text box contains the overall workload expression as entered by the user from the interfaces above.
Parentheses Buttons	These buttons are used to select parentheses to group parts of the overall workload expression. Select a parenthesis by clicking on the left or right button. The use of parentheses is optional.
Primary Operator	The Primary Operator is the MOS and crew position that will be assigned to perform the task.
Repeating Segments	A Repeating Segment is one in which IMPRINT's maintenance model will attempt to send more systems out to perform this segment every so often. You can identify the frequency of the segment (e.g., "repeats every four hours").
Replacement Systems	This is the number of old systems that will be replaced in that unit.
Resource/Interface Channels	Resource/Interface Channels are formed by pairing the human resources with the interfaces (e.g., visual/heads up display, motor/control stick). All workload in an Advanced Mission is assigned to a task by setting individual single task demand values for each resource/interface channel used to perform that task.
Scenario Description	The scenario description is a free text field that you can use to document your analysis. It is limited to 255 characters.
Scenario Name	This is the name of your maintenance scenario. You can have many maintenance scenarios for each system.
Secondary Operators	In VACP Missions, you can select one or more secondary operators for each task. The only role a secondary operator plays is that they will be considered during the task reallocation process (under the Adjust menu), if workload overload occurs during your mission execution.
Segment Cancellation Time In Hours	This is the number of hours that the simulation will wait for the minimum number of systems to be available before canceling the segment. For example, if the minimum number of systems for this segment is six and there are only four available at the scheduled start of the segment then the segment must wait. If there is a value of "1" in this field, then if the minimum number of systems do not become available within one hour of the scheduled start, the segment will be canceled. The default value for this item is 0. This means that the minimum number of systems must be available at the start time of this segment in order for the segment to begin. Be very careful that your cancellation is not after the segment would attempt to repeat.
Segment Duration Time in Hours	This value indicates the number of operational hours for this segment. This value is used to schedule the return of the systems from operations and the beginning of the maintenance window. Additionally, this time is used to determine usage for the equipment on which failures are triggered by time.
Segment Priority	When more than one segment has been defined to occur at the same time, the segments must compete for available systems. In this box, you can

	enter a priority number for each segment. The segment with the higher priority value will get available systems first.
Segment Repeat Time in Hours	If you have indicated that the segment will repeat, you will be able to enter data in this box. The value in this box controls the frequency with which the simulation will attempt to repeat this segment. If you will enter the number 4 in this box, it will indicate that you want this segment to repeat every four hours. In other words, this segment will try to start again every four hours throughout the simulation. If you wanted this segment to repeat only twice, you could do this by defining two separate but identical segments with one starting four hours after the first.
Segment Start Day	This box and the one labeled Segment Start Time work together to identify the start time of this segment. This value defaults to 1. If you were to leave the default values in both of these boxes, this mission would begin at time 0 on day 1.
Segment Start Time	This box contains the an indication of when you want this segment to begin. This value defaults to 00:00:00.00.
Shift Data	Enter the maintenance shift length in clock hours and the number of shifts per day. The product of the two numbers must be less than or equal to 24. The number of shifts will determine the number of columns in the manning spreadsheet
Subsystem Equipment Type	The subsystem type indicates the operational units that are used to describe the usage for that subsystem. Usage for an armament subsystem is described as the number of rounds that have been fired from that subsystem. Usage for components in a distance subsystem is described in terms of the number of miles that the system has traveled. Subsystems with a type of "Other" use operational time as the usage measure.
Subsystem Name	This column of the spreadsheet contains the name of the subsystem. Names must be unique.
Subsystem Type	The subsystem type indicates the operational units that are used to accrue the usage for that subsystem. Usage for an armament subsystem is described as the number of rounds that have been fired from that subsystem. Usage for components in a distance subsystem is described in terms of the distance that the system has traveled. Subsystems with a type of "Other" use operational time as the usage measure.
Task Accuracy Description	The task accuracy description is a combination of a numerical value and a measure which, taken together, indicate the accuracy performance standard for a task.
Task Accuracy Mean and Standard Deviation	This option allows you to specify an average value for how accurately a particular task is likely to be performed. For example, you might say that on the average when performing this task the operators get 90 percent of the steps correct or for another tasks, they are within 10 mils of the correct azimuth. Under the first option, you will also specify the standard deviation, which in some sense is a measure of the worst and best the task is likely to be performed. An easy rule of thumb for specifying the standard deviation is to compute the difference between the worst and best

	performance and divide it by 6. For example, if the worst performance is 40% steps correct and the best is 100%, then an estimate for the standard deviation would be 10% ($((100 - 40)/6) = 10$). Under this option you will define what is acceptable performance by specifying an accuracy standard. For example, you may say that any error greater 5 mils causes firing inaccuracies that are unacceptable. With the information above, the model then computes the probability of the task performance being at or above the standard and compares a selected random number to determine if task was performed accurately.
Task Accuracy Probability	This option "Probability of Success" skips the requirement for specifying all the detailed data (i.e., mean, standard deviation, and accuracy standard) in the option above and goes straight to specifying a probability of success, which again is compared with a random number to determine if the task was performed accurately.
Task Criterion	The task criterion indicates the percentage of time that the task must meet its time and accuracy standards in the same simulated occurrence.
Task Mean Time	The task mean time value is used in conjunction with the task standard deviation and the distribution type to generate a predicted performance time for this task. When IMPRINT runs, a random number is generated and is used to pull a number from the distribution you have specified. This number becomes the task time for that occurrence of the task.
Task Name	This text box displays the name of the task for which you are displaying or entering information. To move from one task to another use the "Previous"
Task Priority	Task priorities are used to execute priority-based workload management strategies. The priorities range from 1 (very low) to 5 (very high). New tasks are assigned a priority level of 3 (medium). To change a priority level for a task, double click on a task to open the task parameter window, click in the Task priority field of the task and enter a priority value between 1 and 5, or click on the drop box in the task priority field and select a priority from the list.
Task Standard Deviation	The task standard deviation value is used in conjunction with the task mean time and the distribution type to generate a predicted performance time for this task. When IMPRINT runs, a random number is generated and is used to pull a number from the distribution you have specified. This number becomes the task time for that occurrence of the task.
Task Time Distribution	The task time distribution is used in conjunction with the task standard deviation and the task mean time to generate a predicted performance time for this task. When IMPRINT runs, a random number is generated and is used to pull a number from the distribution you have specified. This number becomes the task time for that occurrence of the task. IMPRINT contains normal, log normal and gamma statistical distributions.
Task Time Standard	The Time Standard is the slowest performance time that can be tolerated and have the task still be considered a success. When IMPRINT executes your mission model, the Estimated Task Mean Time, Standard Deviation,

	and Distribution are used to choose a specific task time for each occurrence of each tasks. These times are then accumulated throughout the model run and compared to the time standard in order to report the percentage of successes for each task. To enter the time standard, use the mouse to position the cursor in the time standard box. The format for this entry (as with all other time values) is hh:mm:ss.00. So to enter a time standard of 30 minutes, 15 seconds enter 00:30:15.00. Notice that you can enter hundredths of a second after the decimal point.
Time Between Departures in Minutes	This value is the time between when each group departs to perform their segments.
Time Format	To enter any time data, use the mouse to position the cursor in the time standard box. The format for all time values is hh:mm:ss.00. So to enter a time standard of 30 minutes, 15 seconds enter 00:30:15.00. Notice that you can enter hundredths of a second after the decimal point.
Unit Description	This option lets you identify the unit that you are modeling and the number of systems in that unit. This information is used in IMPRINT to determine the Force-level manpower and personnel requirements of your system.
Unit Sizes	This drop down list is used to choose the size of the unit being listed on the Force Structure dialog. The unit sizes are: Corps, Division, Brigade/Regiment, Battalion, Company/Battery/Troop, Platoon, Section, Other.
Warm-up Period in Days	If you would like to let the model execute for a few days to "ramp up," you can cause the model not to collect any data until after the number of days you enter in this field has passed. For example, if you want to collect thirty days of data from the model but you also want to let the model run for three days before beginning to collect data, you need to enter 33 days in the "Number of days to simulate" field and 3 days in this field. This value defaults to 0.

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Appendix A - Technical Description of Stressor Implementation

Evaluation of Human Performance under Diverse Conditions
via Modeling Technology

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Streamlined system acquisition and resource constraints are realities of military test and evaluation today. However, the pressure of saving time and dollars cannot be permitted to eliminate the assessment of total system performance - that is, the soldier, the hardware, and the software. Assessing combined soldier-system performance is as critical as ever. To address the challenges of the future battlefield requirements documents being written for military systems today regularly require operation in cold and hot conditions; in nuclear, biological, and chemical (NBC) environments; and over extended time periods. More and more functions are required to be automated, which does not necessarily make the job easier but, more likely, changes the nature of the job, the crew size, the task allocation, and the skills and abilities needed to do the job. These kinds of system requirements generate soldier-system dynamics that will affect overall system performance and must be evaluated throughout the system acquisition, design, and, ultimately, the test and evaluation process.

In addition to the time and cost-effectiveness considerations that are givens for test and evaluation, regulations governing human use and test participant safety must also be considered. It is simply not permitted to test systems under all of the actual conditions in which they are required to operate. Certain hazardous conditions, for example, NBC operations, must be approximated. It is being proposed here that modeling not only provides a reasonable alternative for the approximation of performance under diverse--even extreme--conditions, but it also can be accomplished within the time and cost constraints. Existing data can be used to extrapolate to other conditions. Once a baseline model is built, excursions are typically straightforward. Modeling can be used iteratively to evaluate different conditions or to conduct sensitivity analyses and comparisons.

Over and above the ways in which modeling technology helps to address the time, cost, and safety concerns of test and evaluation, it offers a logical and sound approach to estimating human performance. It is a task-analytic approach that lends itself to good documentation and the building of audit trails. It can be used to help quantify what are, all too often, largely subjective assessments. It can also compensate for, or be used to extend operational field data that come with certain innate limits such as uncontrollable extraneous variables, small sample size, and non-repeatability. Modeling too, has its limitations; however, in combination with more traditional test and evaluation methods, for example, in a model-test-model mode, it can provide valuable estimates of human performance under a wide variety of conditions.

The IMPRINT Tool. The U.S. Army Research Laboratory Human Research and Engineering Directorate has developed a modeling and analysis tool, the Improved Performance Research Integration Tool (IMPRINT). The IMPRINT tool grew out of common U.S. Air Force, Navy, and Army manpower, personnel, and training (MPT) concerns identified in the mid-1970's: How to estimate MPT constraints and requirements early in system acquisition and how to enter those considerations into the design and decision-making process. The U.S. Navy first developed the HARDMAN (Hardware vs. Manpower) Comparability Methodology (HCM). The Army then tailored the manual HCM, which became known as HARDMAN I, for application to a broad range of weapon systems and later developed an automated version, HARDMAN II. In HARDMAN I and II, however, there was no direct link between MPT and performance. To directly remedy this shortcoming, the U.S. Army began the development of a set of software analysis modules in the mid-80's (Kaplan, 1988). This set of modules was called HARDMAN III, and although the name was the

same, it used a fundamentally different approach for addressing MPT concerns than previous methods: It provided an explicit link between MPT variables and soldier-system performance. IMPRINT, while being an improvement over HARDMAN III, for the purpose of the discussion here, is essentially HARDMAN III in the Windows™ environment.

The mechanism for the MPT-performance link is task network modeling provided by the commercially- available Micro Saint task network simulation modeling engine, PC software designed for describing and analyzing task networks. The modeling capability offered can be further characterized based on three distinctions (Law & Kelton, 1991): (1) static vs. dynamic, (2) deterministic vs. stochastic, and (3) continuous vs. discrete. A static model does not address system effects over time, whereas a dynamic model represents a system as it changes with time. A deterministic model does not represent any probabilistic, or random, elements. A stochastic model does encompass random elements and produces output that contains random error. A discrete model refers to instances where the variables characterizing the system change instantaneously at separated points in time. A continuous model is the converse, with variables that change continuously with time. In some instances, systems can be treated as either discrete or continuous, depending on the objectives of the analysis.

Using these definitions then, IMPRINT can be described as a dynamic, stochastic, discrete event modeling tool. When certain assumptions hold, namely, that the system of interest can be adequately described by task activities and networked sequencing, that dynamic processes and random variability are of interest, and that any continuous tasks can be fairly transformed into discrete tasks, then IMPRINT is an appropriate tool to use to represent and analyze soldier-system performance.

The basic modeling capability in IMPRINT requires the decomposition of a system mission into functions which, in turn, are decomposed into tasks. The functions are linked together into a network describing the flow of events. The network can include various types of branching logic such as parallel branches, probabilistic branches, and repeating branches. Within each function, the tasks are sequenced using the same types of branching logic options. At the task level, estimates of task performance time and accuracy means and standard deviations are input along with the consequences of the failure to perform a task accurately enough. The failure consequence options are no effect, total mission abort, repetition of that or some other task, or subsequent degradation of some other task. The data entered are assumed to be representative of performance under “typical” or baseline conditions. Also, standards of performance can be entered to provide benchmarks for performance adequacy at the mission, function, and task levels. A sample IMPRINT screen depicting both the function and task level networks is shown in Figure 1.

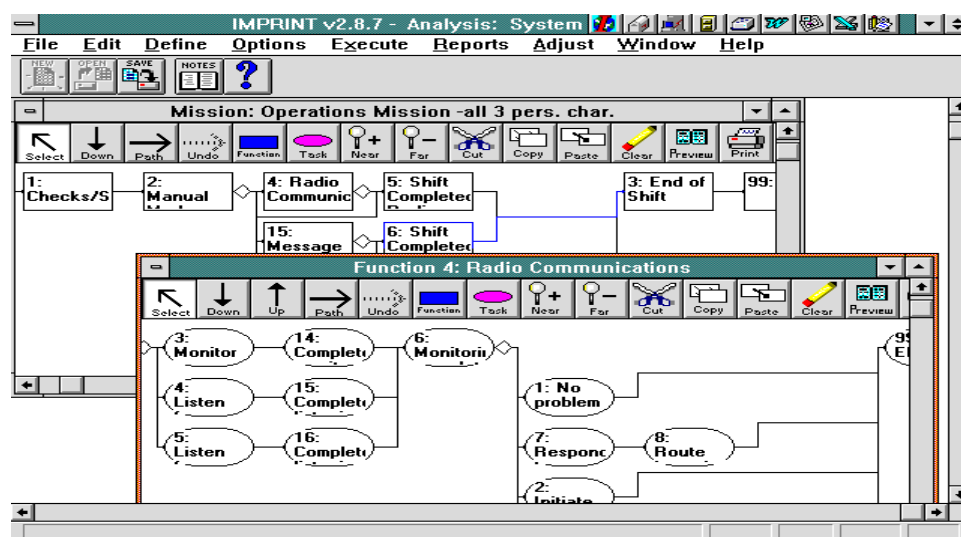


Figure 1. Sample IMPRINT Function and Task Network Windows.

IMPRINT executes a mission model task-by-task by first drawing a task time from the distribution as

defined by the mean and standard deviation input for each task. (IMPRINT assumes a default normal distribution although other distribution options are available). Then it calculates the probability of success for the task based on the accuracy inputs. Next it determines, for this instance, whether there is an accuracy failure. After checking for a given task, IMPRINT proceeds through the task and function networks in accord with the established branching logic and analyzes the output according to the standards. When the model execution is completed (which can be anywhere from 1 to 999 repetitions), reports of estimated performance at each of the three levels are generated along with the comparisons to the standards. Although any given model and its associated assumptions must be scrutinized, this approach is particularly useful for comparisons across systems or system conditions.

The Environmental Stressors in IMPRINT. Along with the basic task network simulation modeling capability, the IMPRINT tool includes specific algorithms or look-up tables--environmental stressors--to assess performance under diverse conditions. Recall that the task performance data entered in the baseline model are assumed to represent performance under “typical” conditions. The embedded environmental stressors automatically adjust performance to account for the changes expected under different levels of the stressors. Currently, IMPRINT includes five environmental stressors: protective clothing (i.e., Mission-Oriented Protective Posture or MOPP), heat, cold, noise, and hours since last sleep (see Figure 2). The application of a stressor will result in either less accurate task performance, longer times to complete the task, or both. Stressors may be applied to an individual task or to all the tasks assigned to a particular job or Military Occupational Specialty (MOS) for the mission. When the model is re-run, the new, or “stressed,” task performance time and/or accuracy are used as the task estimates that are “rolled up” in the task, function, and mission reports and compared against the standards. Importantly, the results can also be compared with the baseline model predictions. (See Dynamics Research Corporation, & Micro Analysis & Design, 1993) for more complete documentation.)

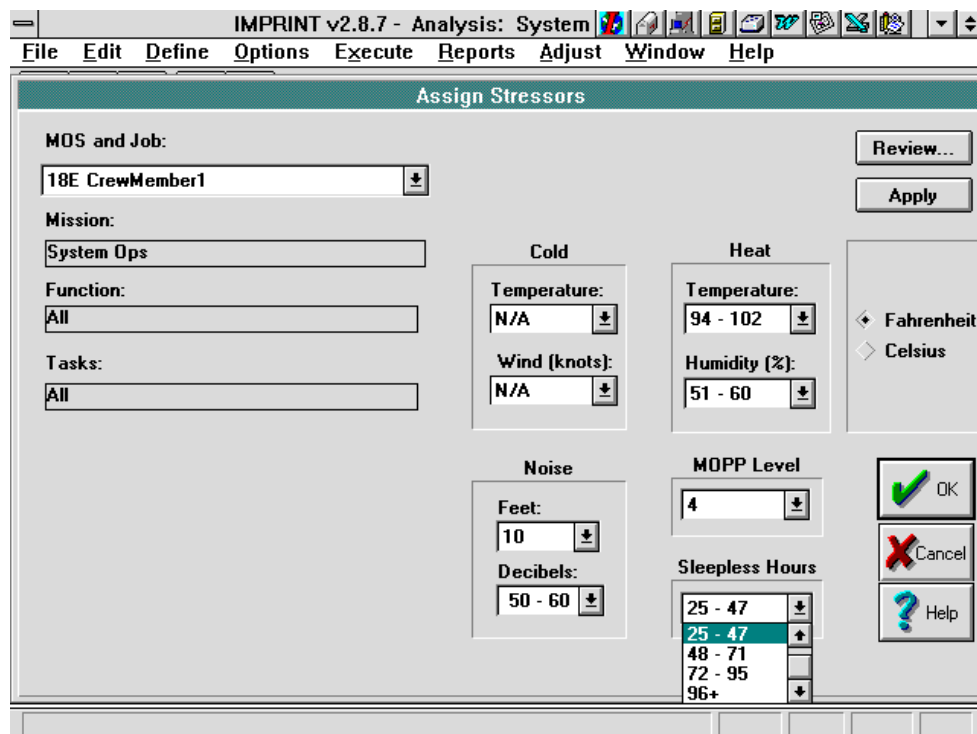


Figure 2. IMPRINT Window Showing the Environmental Stressor Options.

As a side note, IMPRINT also models the effects of two task performance shaping functions, based upon personnel characteristics and training frequency and recency. The personnel characteristics function uses both standardized MOS entrance scores and the general Armed Forces Qualification Test (AFQT)

scores. Different from the stressors, which only degrade performance, applying the performance shaping functions can result in either better or worse performance, depending on the level selected. For example, increasing the frequency of training results in improved performance, whereas decreasing the frequency lowers performance. IMPRINT also models the mental workload associated with task performance. Workload profiles can be developed for crew members, or, in the advanced mode, the interaction of workload and performance can be evaluated to include workload coping strategies and task-workload conflicts. Although these functions provide important analytic capabilities, the focus of the paper from this point is solely on the environmental stressors.

Before discussing each stressor in turn, it is important to note that not all tasks are affected in the same way or by the same stressor. To accommodate this, IMPRINT uses a task category weighting scheme. Nine categories or taxons used to describe a task (see Table 1) (Fleishman & Quaintance, 1984). Category weights are assigned to each task so that the various stressor effects are likewise weighted. In this way, each task contributes only the appropriate amount of change to the “stressed” performance at the mission level. Every task can be categorized with as many as three taxons. For example, operating a tractor and semi-trailer may involve driving a vehicle that is classified as “fine motor continuous” and may involve giving or receiving instructions, which is classified as “communication (oral).” Additionally, weights, which must sum to 1.0, are used to describe the degree to which a particular task manifests a particular taxon. In the example cited, operating a tractor and semi-trailer task might be composed of .75 fine motor continuous and .25 communication (oral). Modification of the taxon weights also allows for the consideration of new technology. For example, an automatic reloading device could change a heavy lifting or gross motor heavy task to a fine motor discrete task where only the manipulation of controls is required.

Table 1. The Nine IMPRINT Taxons, Their Descriptions, and Task Examples

Taxons	Definitions	Examples
Visual	Requires using the eyes to identify or separate targets or objects	<ul style="list-style-type: none"> • Seeing something move and then recognizing it as an enemy tank
Numerical	Requires performing arithmetical or mathematical calculations	<ul style="list-style-type: none"> • Measuring an azimuth on a map with a protractor • Estimating the distance between two points on a map
Cognitive (Problem Solving and Decision Making)	Requires processing information mentally and reaching a conclusion	<ul style="list-style-type: none"> • Locating a fault in an electrical system after troubleshooting • Selecting the best firing position for a machine gun
Fine Motor Discrete	Requires performing a set of distinct actions in a predetermined sequence mainly involving movement of the hands, arms, or feet with little physical effort	<ul style="list-style-type: none"> • Assembly and disassembly of the M-16 rifle • Starting the engine of a truck
Fine Motor Continuous	Requires uninterrupted performance of an action needed to keep a system on a desired path or in a specific location	<ul style="list-style-type: none"> • Driving a vehicle • Tracking a moving target
Gross Motor Heavy	Requires expending extensive physical effort or exertion to perform an action	<ul style="list-style-type: none"> • Lifting an artillery round • Loosening a very tight bolt with a wrench
Gross Motor Light	Requires moving the entire body (i.e., not just the hands) to perform an action without expending extensive physical effort	<ul style="list-style-type: none"> • Getting into a prone firing position • Evacuating a tank
Communication (Read and Write)	Requires either reading text or numbers that are written somewhere or writing text or numbers that can be read	<ul style="list-style-type: none"> • Reading a preventive maintenance check list for a vehicle • Writing a letter home
Communication (Oral)	Requires either talking or listening to another person	<ul style="list-style-type: none"> • Giving a situation report by radio • Receiving a password from someone while on guard duty

Table 2 details which task taxons are affected by which stressors in the current IMPRINT software. It also shows whether the task performance is degraded by time, accuracy, or both. Since degradation factors are processed as multipliers, the degradation factors affecting time will be greater than 1.0 to increase the performance time. On the other hand, the degradation factors affecting accuracy will be less than 1.0 to decrease the performance accuracy from the pre-existing accuracy level. The overall degradation resulting from a specified stressor is directly proportional to the weighting assigned to the affected taxon(s) comprising the task.

Table 2. Listing of the IMPRINT Environmental Stressors and the Taxon Types Affected by Either Time or Accuracy or Both.

Taxon	MOPP	Heat	Cold	Noise	Sleepless Hours
Visual	T	A	T		
Numerical		A			TA
Cognitive		A			TA
Fine Motor Discrete	T	A	T		
Fine Motor Continuous					
Gross Motor Light	T		T		
Gross Motor Heavy					
Commo. (Read & Write)		A			
Commo. (Oral)	T	A		A	

where T = Affects task time only

A = Affects task accuracy only

TA= Affects task time and accuracy

MOPP. The effect of MOPP gear on task performance is modeled as a function of levels of MOPP gear and task taxon. As shown in Table 2, MOPP affects the time that it takes to complete tasks described by the visual, fine motor discrete, gross motor light, and communication (oral) taxons. The degradation factors were derived from a series of studies conducted by the former Ballistic Research Laboratory (Wick, 1988) where the measure of performance degradation for each task was the time difference between performing the task in Battle Dress Uniform (BDU) and performing it in MOPP 4. Each task was later described in terms of ten human ability codes. These codes were mapped to the IMPRINT taxons and the degradation factor for each taxon was computed as the average of the mapped degradation factors by human ability code. MOPP level 0 is equivalent to BDU and therefore has a degradation factor of 1 that correlates to “no degradation.” Degradation factors are applied as multipliers against the time that it takes to complete a task in BDUs. The most degraded performance is under MOPP 4 for fine motor discrete tasks and for oral communication tasks that take 1.7 times as long to perform. (The entire set of matrices of degradation factors for the stressors is not provided here but is available from the author on request.)

Heat. IMPRINT models the effects of heat on task performance accuracy as a function of dry bulb temperature and relative humidity using degradation factors based on various published reports and documents. Research relating heat stress to inaccurate performance (e.g., Ramsey & Morrissey, 1978) was referenced. The MIL-HDBK-759-A (1981) was used to determine the effective temperature for different combinations of dry bulb temperature and relative humidity. And, data on the average number of mistakes per man-hour as a function of effective temperature from the Bioastronautics Data Book (1981) were included in the derivation of the heat degradation factors. The derived factors applied solely to sedentary type tasks. Thus, the taxons affected are visual, numerical, cognitive, fine motor discrete, communication (read and write), and communication (oral). No degradation in accuracy performance is seen until the temperature reaches approximately 113° F (or 45° C) and the humidity reaches approximately 50%. Performance falls to essentially zero when the temperature reaches approximately 130° F (or 55° C) and the humidity reaches approximately 80%.

Cold. Cold weather degradation factors affecting task time performance are modeled in IMPRINT as a function of ambient temperature and wind velocity. Two functional relationships were developed from a study (Teichner, 1958) that related wind chill to percentage of performance loss. One relationship was developed for visual reaction time, thus providing the data for the visual and fine motor discrete taxons; the other was developed for manual skills, providing the data for the gross motor light taxon. The degradation factors for cold are computed as the percent loss of performance as a function of wind chill, wind chill being a function of wind velocity and ambient temperature. Time effects range from a minimum of 1.03 times as long for temperatures of approximately 35° F (or 1° C) and a wind velocity of approximately 10 knots to a maximum of 1.70 times as long for temperatures of approximately -40° F (or -40° C) and a wind velocity of greater than 50 knots. Note that this degradation does not account for prolonged exposure to cold and wind.

Noise. The way in which IMPRINT models the effect of noise on task performance is based on the effectiveness of voice communications as a function of noise level and distance between the speaker and the listener. As shown in Table 2, the degradation that results from various noise levels affects the accuracy with which a task that requires oral communications between two or more people is performed. The effect of noise on task accuracy and the resultant degradation factors were derived from a graph in MIL-STD-1472C. Distances modeled range from 1 to greater than 20 feet and noise levels range from 50 to greater than 110 dB PSIL. Approximately midway through the ranges modeled, accuracy of performance essentially drops to zero, as might be expected.

Sleepless Hours. In IMPRINT, sleepless hours refers to extended operations or the lack of sleep. It is important to note that sleep deprivation is the only environmental stressor that causes degradation in both the time to perform a task and the accuracy with which it is performed. IMPRINT models the stress of continuous operations as a function of hours since last sleep. Ranges of hours since last sleep go from 24 hours to greater than 96. At the 96-hour range, time to perform tasks is essentially doubled and accuracy has dropped to zero. The factors included in IMPRINT were derived from a review of several studies (Belenky et al., 1987), which found that the only taxons that are affected by lack of sleep are numerical and cognitive. Of note, in contrast to cognitive performance, physical strength and endurance are relatively unaffected by lack of sleep and can be restored by simple rest.

Multiple Taxons with Multiple Stressors. Many combinations of multiple stressors and taxons are also implemented in IMPRINT. Table 3 shows the possible combinations of stressors and the associated taxons. When two or more different stressors affect a task's taxon in time or accuracy, the overall degradation is not just the sum of the individual degradations. In fact, the overall degradation is less than the sum of the individual degradations. As more stressors are added, they have less than the full effect on performance. Normally, the most severe stressor will have a full effect on performance. As additional stressors are added, they will have less and less impact on performance accuracy and time. This phenomenon is approximated with a power function (Harris 1985).

Table 3. Possible Combinations of Stressors and Taxons Implemented in IMPRINT.

Stressors	Taxons
MOPP & Heat	Visual Fine Motor Discrete Communication (oral)
MOPP & Cold	Visual Fine Motor Discrete Gross Motor Light
MOPP & Noise	Communication (oral)
Heat & Noise	Communication (oral)
Heat & Sleepless Hours	Numerical Problem Solving
MOPP & Heat & Cold	Visual

	Fine Motor Discrete
MOPP & Heat & Noise	Communication (oral)

IMPRINT Verification, Validation, and Accreditation (VV&A). HARDMAN III, the IMPRINT predecessor was subjected to a formal VV&A process, the first of its type in the U.S. Army. The first phase, which is applicable here, comprised the core task network modeling capability and the effects implemented as additions to or modifications of the task data--mental workload estimation and environmental degradation, personnel characteristics, and training. A review board of representative users, policy-makers, technical experts, and soldier proponents evaluated the findings against eight criteria: configuration management, software verification, documentation, data input requirements, model granularity, validity of modeling techniques and embedded algorithms, output, and analysis timelines. All criteria were satisfied and formal accreditation was granted in January 1995 with only limited caveats (see Allender et. al, 1995).

Since the environmental stressors were transitioned to IMPRINT without modification, the basic VV&A transitioned as well. Of note, although this portion of the software was approved and the basic approach of degrading time and/or accuracy of performance on a task-by-task basis was supported, the consensus was that all the algorithms warrant updating and that new algorithms need to be developed to fill the voids. Referring to Table 2 and to the dates of some of the environmental stressor references, it is clear that there are substantial voids and that there is certainly new research that should be accounted for in this arena.

Examples of the Method for Test and Evaluation. One example of the implications of this modeling approach to the test and evaluation arena was reported by Allender, McAnulty, and Bierbaum (1992). They describe the application of the predecessor HARDMAN III software to the analysis of potential options for reducing turnaround time in an Apache Forward Arming and Refueling Point (FARP). Once the baseline was constructed, three options were compared: adding a new equipment component, adding personnel, and changing reloading tactics, that is full vs. half reload of one ammunition type. The level of effort involved in the evaluation of options was only a fraction of the baseline development costs and certainly only a fraction of comparable field trials. Since the modeling effort was conducted at the same time as the test planning was under way, the results were available to the test planners to help focus testing and to serve as a validation reference. They asserted that the results were appropriate to be used in interaction with testing, not as a substitute.

Another example is the work reported by McMahon, Spencer, and Thornton (1995). Within months of a final milestone review, an NBC reconnaissance system called the Fox had been given an "unacceptable" operational assessment at the completion of a large-scale field test. The central issue was that a four-seat vehicle had not been modified to fit the new three-person crew. The operator was forced to switch positions repeatedly in order to do the job, which caused safety problems and unacceptable performance. Coupled with modeling of proposed changes to the equipment and display layout, two mission models were built: the baseline and the proposed re-design. The mission model predicted substantially reduced workload and improved performance. Subsequently, the system was retro-fitted for a limited, two-week test which validated the model predictions. From this example the time, cost, and even safety benefits of using modeling in conjunction with testing are quite evident.

Proposed Environmental Stressor Developments. The examples provided in the previous section are good evidence for the utility of modeling in the test and evaluation arena; however, a comprehensive application of the environmental stressors for test and evaluation has not been completed. This is clearly a priority. Also, the shortcomings, voids, and need for updates to the stressors are obvious.

At this time, the literature in this area is being re-surveyed in order to develop a prioritized list of stressor updates, enhancements, and additions. Criteria for the prioritization are user need and availability of generalizable data. Several other organizations have also identified this type of work as critical and plans

for leveraging and cooperation are under way. Work of note includes that being performed under the auspices of the United Kingdom Defence Evaluation Research Agency Centre for Human Sciences, the Integrated Performance Modeling Environment. The U.S. Defense Special Weapons Agency (formerly the Defense Nuclear Agency) has published work in this area also (e.g., Anno, Dore, & Roth, 1996). Close at hand, the U.S. Army Research Laboratory Human Research and Engineering Directorate is currently investigating databases on various dimensions of psychological stress as related to performance for inclusion in IMPRINT.

In conclusion, the IMPRINT tool offers a modeling technology for evaluating human performance under diverse conditions. Based on sound task analysis, network modeling, and environmental stressor degradation algorithms tailored to task type, assessments of performance under diverse conditions can be used to augment test and evaluation today. With continued development, the capability to perform these types of analyses will be further enhanced.

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Appendix B - Human Performance MicroModels

Perceptual Models

Basic Parameters

Eye Movement Time (target located in eye field)	100 msec (travel time only)	Houtmans & Sanders, 1984; Sanders & Houtman, 1985
Head Movement Time (target located in head field)	200 msec (travel time only)	Houtmans & Sanders, 1984; Sanders & Houtman, 1985
Eye Fixation Time	100 msec - 500 msec	Houtmans & Sanders, 1984; Sanders & Houtman, 1985
Search Time	$(T_m + T_f)N$ where N = number of fixations, T_m = movement time, T_f = fixation time	
Reading Rate	52 words/min (5 saccades per word), 261 words/min (1 saccade per word), 652 words/min (1 saccade per phrase), Assumes: 5-letter words, 2.5 words or 13 characters per phrase	Card et al., 1983
Listening	Rate: 2.4 words/sec	Miller and Licklider, 1950

Motor

Basic Parameters

Hand Movement (Fitt's Law-Welford Variant)	$I_M \log_2 [D/S + 0.5]$ where T = Movement Time, D = Distance between targets, S = Size of Targets, I_M = Slope Constant = .1 sec/bit	Welford, 1968
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Hand Controls

Pushbutton or Toggle	400 msec	Harris et al., 1988
Rotary Dial	730 msec	Harris et al., 1988

Cursor Movement with Trackball	$IM * \log_2 (d/s + 0.5)$ where IM = constant = 100 msec/bit, d = cursor distance to be moved, s = display symbol width	Harris et al., 1988, from Fitt's Law
Cursor Movement with Mouse	$1.03 + .06 \log_2 (D/S + .5)$ sec, D = Distance to target, S = Size of target	Card et al., 1983
Cursor Movement with Joystick	$KD + .100 \log_2 (D/S + .5)$ sec where KD = intercept distance for distance D, D = Distance moved, S = Size of target	Card et al., 1983
Cursor Movement with Step Keys	$98 + .074 (D_x/S_x + D_y/S_y)$ sec, where D_x =Horizontal distance to target, D_y =Vertical distance to target, S_x =Size of a vertical step (default = .456 cm), S_y =Size of a horizontal step (default = .246 cm).	Card et al., 1983
Cursor Movement using Text Keys	$.66 + .209 N_{min}$ sec. where: .209 = Keystroke rate (in sec/keystroke) which approximates the typing rate for random words, N_{min} = minimum number of keystrokes.	Card et al., 1983
Single Finger Keying Rate	.140 [.060 = .200] sec	Card et al., 1983
Typing Rate	.209 sec/keystroke	Card et al., 1983
Walking Rate	0.19 sec/foot	Harris, 1988

Speech

Speech rate	3.4 words/sec (large vocabulary), 2.4 words/sec (small vocabulary)	McCormick, 1970
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Cognitive

Basic Parameters

Perceptual Process	$\tau_P = 100$ msec	Card et al., 1983
Decision Process	$\tau_C = 70$ msec	Card et al., 1983

Motor Process	$\tau_M = 70 \text{ msec}$	Card et al., 1983
Simple Reaction Times - On/Off Response	$\tau_P + \tau_C + \tau_M = 240 \text{ msec}$	Card et al., 1983
Simple Reaction Times - Physical Match	$\tau_P + 2\tau_C + \tau_M = 310 \text{ msec}$	Card et al., 1983
Simple Reaction Times - Name Match	$\tau_P + 3\tau_C + \tau_M = 380 \text{ msec}$	Card et al., 1983
Simple Reaction Times - Class Match	$\tau_P + 4\tau_C + \tau_M = 450 \text{ msec}$	Card et al., 1983
Choice Reaction Time	$K * \log_2(n+1)$ where: k is a constant representing simple RT and is set at 150 msec., n is number of possible alternatives	Hick's Law as discussed in Card et al., 1983
Mental Rotation (Visualization)	$1 \text{ sec} + (R / 50^\circ \text{ per sec})$ where: R = amount of rotation from initial perceived view to final visualized view (in degrees)	Shepherd and Metzler, 1971

Special

Prioritization (i.e., of targets)	$.310[n(n+1) / 2]$ where: n = number of targets in a sector. This formula treats prioritization as a unidimensional [worth] pairwise comparison between all possible targets in a sector.	McCarthy and Plocher, 1990
Terrain Association	Two stage process: Stage 1. Reduce size of area of uncertainty: Time = 5 sec. (Performed once every time a completely new view is encountered.), Stage 2. Pinpoint own location Time = 2 sec. Per terrain matching attempt. (Four to seven matching attempts required to pinpoint own location. Other job activities are typically interspersed in between terrain matching attempts.)	Cross, Rugge, and Throndyke, 1982

